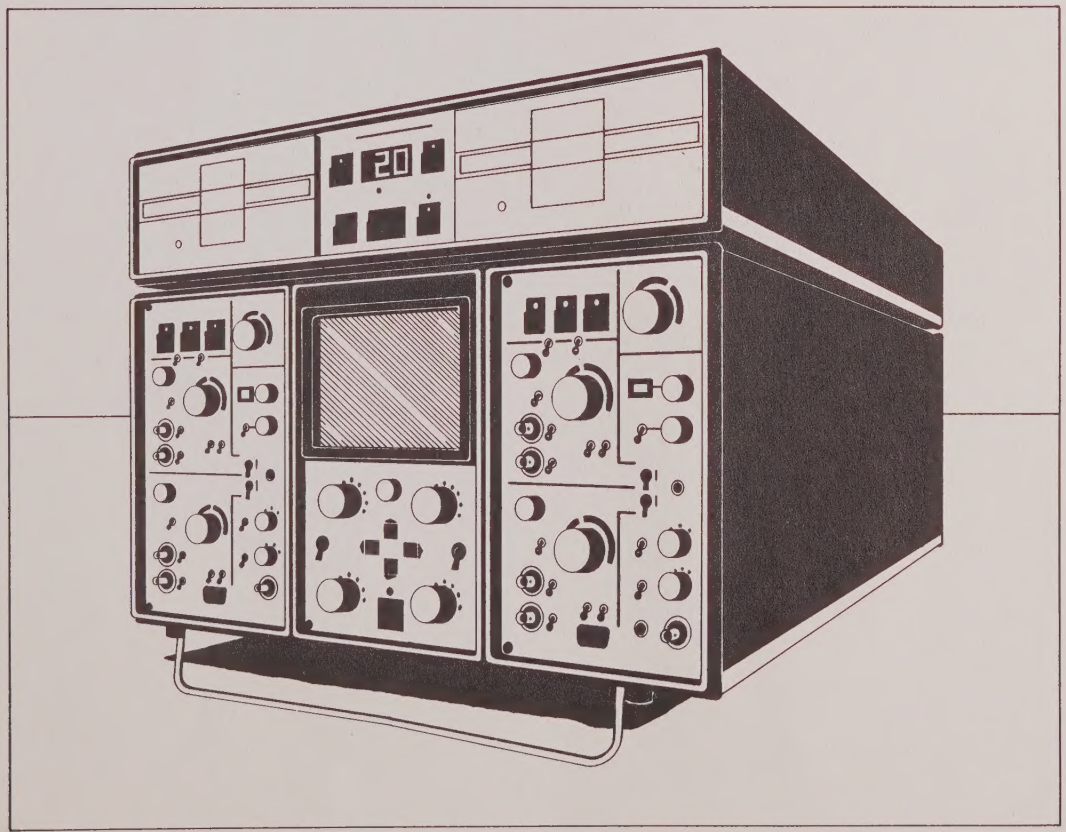
NICOLET
INSTRUMENT
CORPORATION
OSCILLOSCOPE DIVISION

# OPERATION MANUAL

## SERIES 4094 DIGITAL OSCILLOSCOPES

PRELIMINARY MANUAL - Subject to change



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## CAUTIONS

CAUTION: This instrument and related accessories are not designed for biomedical experiments on humans and should not be directly connected to human subjects.

CAUTION: This instrument must not be operated in explosive atmospheres.

The following information is required by the FCC and relates only to the interference potential of this equipment. This message is a direct quotation. Although stated as a "Warning", there is essentially no risk of injury, loss of life, or equipment damage.

WARNING: This equipment generates, uses, and can radiate radio frequency energy and if not installed and used in accordance with the instructions manual, may cause interference to radio communications. As temporarily permitted by regulation, it has not been tested for compliance with the limits for Class A computing devices pursuant to Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference. Operation of this equipment in a residential area is likely to cause interference in which case the user at his own expense will be required to take whatever measures may be required to correct the interference.

WARNING: Inspect the voltage selection switch, Figure 5-2, located at the rear of the 4094 for the correct setting BEFORE applying power. Use Table 5-1 to verify the correct setting.

*Page 5-2*

WARNING: Before applying power to this instrument, refer to the *Receiving & Pwr Req's* tab, page 5-2.

*Pages 7-3, 7-9 & 12-3*

CAUTION: Remove all power from the oscilloscope before replacing the fuse.

*Page 7-9*

CAUTION: Always ensure that the input signals never exceed the maximum, allowable input voltage, with respect to ground, listed under tab *Specifications*.

*Page 8-12*

WARNING: To guard against physical damage to the disk heads and/or diskette, ALWAYS open the drive's door when:

a. Power is off, or
b. Applying/removing power, or
c. Drive is not being used, or
d. Transporting the instrument.

*Pages 9-9 & 11-1*

WARNING: Always ensure that the position of the XF-44's POWER selector corresponds to that of the 4094's POWER selector before applying power to either unit.

*Page 11-4*

WARNING: Lethal voltages exist within the XF-44. It should be serviced only by qualified personnel. Remove all power from this instrument before servicing. Reapply power only after all safety measures have been observed.

*Page 11-4*

## GLOSSARY

- ANALOG ZERO: Identified by the position of the Plug-in's trigger crosshair.
- BNC: Connector used to input/output signals.
- DATA GROUP: The displayed input signal.
- DATA POINTS: The small dots, displayed on the screen, representing the discrete, digitized time and voltage coordinates of the analog input signal.
- DIGITAL ZERO: Located at screen vertical center.
- DIGITIZER: Converts analog input signals into discrete, digitized time and voltage coordinates.
- DISK RECORDER: Optional F-43 and XF-44 conversions used to permanently record input signals on a floppy diskette.
- HOLD MODE: The status of the Plug-in when only the Hold Last LED is illuminated. The Live and Hold Next LEDs are turned off.
- LED: A light emitting diode used as a status light.
- LIVE: The status of the Plug-in when input signals are being acquired and stored in the memory.
- MAINFRAME: Includes the display memory, display screen, and controls used to manipulate the displayed input signal.
- MEMORY: Device used to temporarily record the digitized input signal(s).
- NOISE: Undesirable voltage disturbances on the input signal.
- NUMERICS: The alphanumerics readouts on the display screen.

- PLUG-IN: The Model 4562 and 4851 plug-in units containing the digitizing and buffer memory circuitries and the controls used to acquire the input signal(s).

- RESOLUTION: The ability to discern the minimum voltage difference between any two digitized data points and still retain the optimum characteristics of the analog signal.

- SEGMENT: Either one-half or one-quarter of the floppy diskette's record as determined by the position selected on the MEMORY switch.

- SUBSECTION: Either one-half or one-quarter of the display memory's addresses as determined by the position selected on the MEMORY switch.

- SWEEP: The acquisition and display of the input signal. Initiated after a valid trigger has been received.

- TRIGGER: The input signal applied to the Plug-in which, when possessing the required characteristics, will initiate a sweep.

- WINDOW: The voltage span (difference) between two voltage levels.

# SPECIFICATIONS

## MODEL 4094 OSCILLOSCOPE

| | |
|---|---|
| Memory: | 15,872 words by 16 bits. Data may be stored in all of the memory, in either half or in any quarter. |
| Power Requirements: | 96 to 129 Vac or 192 to 259 Vac @ 50-60 Hz (±5%), *** volt-amperes. |
| Display Expansion: | Digital expansions of X2, X4, X8, X16, X32, X64, X128 and X256, horizontal and/or vertical. Display may be automatically centered around the intersection of the horizontal and vertical cursors. |
| Display Mode: | Choice of XY or YT, with either cursor or grid. |
| Cursor Numerics: | Voltage and time in YT display, voltage and voltage in XY display. |
| Grid Numerics: | Voltage and time per grid mark in YT display, voltage and voltage per grid mark in XY display. |
| Data Functions: | Data may be inverted, subtracted, added, moved and output to a pen recorder or computer. |
| Extended Data Functions: | Available with disk option only. |
| Pen Recording: | Control signal to operate an external XY or YT pen recorder as standard. Systems with I/O board also include control signals for a digital plotter.<br><br>In XY mode, information is read out at a variable rate, with many data points per second in featureless regions of the plot, but fewer per second in regions where the pen movement is substantial. The linear velocity of the pen is maintained essentially constant, adjustable to match the speed capabilities of the recorder. Output voltages are nominally 0-5 volts.<br><br>In YT mode, data is output at a constant (variable) rate. |
| Digital I/O (option): | Includes both RS-232C and IEEE-488 I/O. Maximum transfer rate in RS-232 (serial) mode is 9,600 baud; and in IEEE-488 mode, 20 kilobytes/second. Also included is control for a digital plotter. |
| Plug-ins: | Accepts Models 4562 and 4851 Plug-ins. |

** Exact spec's to be verified.*

| PARAMETERS | 4562 PLUG-IN | 4851 PLUG-IN |
|---|---|---|
| Maximum digitizing rate, MHz | | |
| Resolution, percent | | |
| Accuracy, percent of full scale | | |
| Linearity, percent of full scale | | |
| Maximum sensitivity, full scale range, mv | | |
| Maximum voltage range, volts | | |
| Safe overload at minimum sensitivity, volts | | |
| Safe overload at maximum sensitivity, volts | | |
| Amplifier bandwidth at minimum sensitivity, MHz | | |
| Amplifier bandwidth at maximum sensitivity, MHz | | |
| Sample time uncertainty, nSec | | |
| Noise, >100 Hz, µV rms | | |
| Drift/ °C, percent of full scale | | |
| Input impedance, most sensitive amplifier settings, megohms | *Exact spec's to be verified.* | *Exact spec's to be verified.* |
| Input impedance, least sensitive amplifier settings, megohms | | |
| Input bias current, 25° C ambient, pa | | |
| Common mode rejection ratio at maximum amplifier setting | | |
| Common mode voltage range, percent of full scale range setting | | |
| Sweep speed ranges are as indicated at the right, times the maximum speed setting in µSec's per point | | |
| Maximum speed, time per point, µSec's | | |
| Minimum speed, time per point, seconds | | |
| Trigger sensitivity, % of full scale range, internal triggering | | |
| Trigger sensitivity, volts, external triggering | | |
| Trigger range, volts, external triggering | | |
| Trigger range, percent of full scale, internal triggering | | |
| Cursor signal trigger point, percent of one sweep | | |
| Maximum Delayed trigger time delay, hours | | |
| Number of data points per waveform, single channel (Note 1) | | |
| Number of data points per waveform, multiple channels (Note 2) | | |

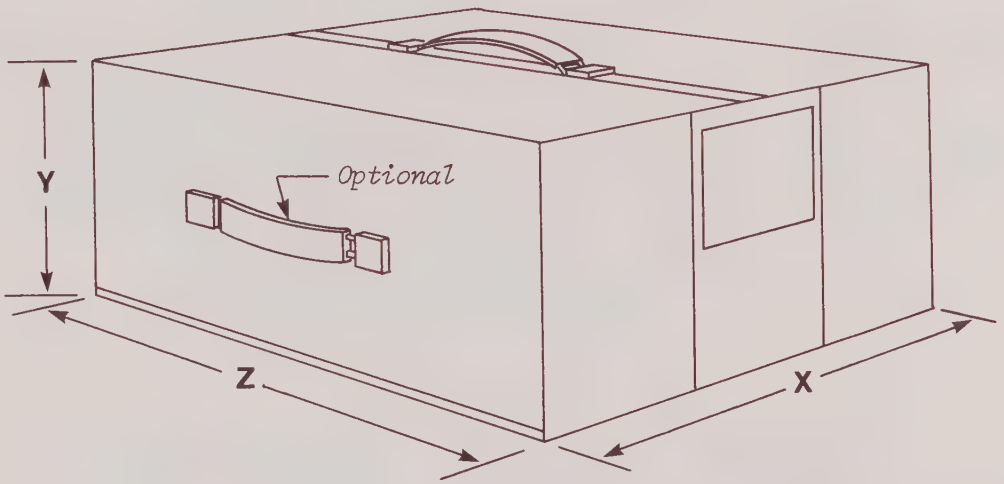
*NOTE 1: The number of data points are selectable via the MEMORY selector switch.*

*NOTE 2: The number of data points are selectable via the MEMORY selector switch and are dependent upon the number of channels being used to acquire data.*

*Divide the listed numbers in the above table by the following factors according to the number of channels involved: Two channels, (2); three or four channels, (4), five thru eight channels, (8).*

## APPROXIMATE DIMENSIONS

MODEL 4094 OSCILLOSCOPE




| | DESCRIPTION | APPROXIMATE DIMENSIONS |
|---|---|---|
| X | Basic Frame Width | 16-15/16" (43.1 cm) |
| | Side mounted carrying handle, add - | 1/2" ( 1.3 cm) |
| | Side mounted bumpers, add - | 1/4" ( 0.6 cm) |
| Y | Basic Frame Height | 8-3/4" (22.2 cm) |
| | Top mounted carrying handle, add - | 1/2" ( 1.3 cm) |
| | Bottom mounted feet, add - | 5/8" ( 1.6 cm) |
| Z | Basic Frame Length | 18-1/4" (46.4 cm) |
| | Front panel control knobs, add - | 5/16" ( 0.8 cm) |

## RECEIVING

Unpack the Model 4094 Digital Oscilloscope and save the carton and packing material in case the instrument must be shipped to another site or returned to the factory for service.

## INSPECTION

Inspect the exterior of the instrument for any visible signs of damage that may have occurred during transit.

If damaged, call NICOLET Oscilloscope Division, Shipping Department, at (608) 271-3333 for instructions.

## POWER REQUIREMENTS

The Model 4094 Digital Oscilloscope's power requirement is nominally *** volt-amperes. It is designed to operate from either of these two single phase power source voltages: 120 or 240 vac, both +8% or -20%.

The power source must include:

#1. A neutral wire at or near ground potential; and

#2. A separate safety ground at ground potential; and

#3. A line (hot) wire.

Figure 5-1 illustrates the locations of the neutral, line, and earth ground terminals located on the male power connector at the rear of the 4094.

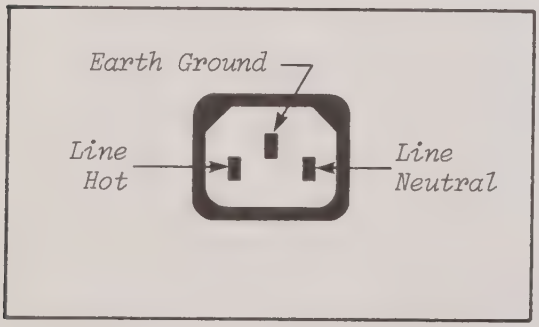



*Figure 5-1*

WARNING: Inspect the voltage selection switch, Figure 5-2, located at the rear of this instrument, for the correct setting BEFORE applying power. Use Table 5-1 to verify the correct setting.

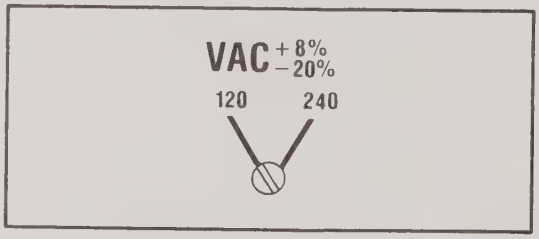



*Figure 5-2*

| SWITCH POSITION | RANGE |
|---|---|
| 120 | *96 - 129V* |
| 240 | *192 - 259V* |

*Table 5-1*

## INTRODUCTION

The Start-up section of this manual provides the operator with a general overview of the 4094 oscilloscope. Users unfamiliar with digital oscilloscope operation will have the most to gain by reading this section.

Only the most common oscilloscope (Mainframe and Plug-in) operations are covered here. Detailed explanations of specific controls are found in the appropriate specialized sections of this manual.

Part I of the Start-up section does not assume the availability of a signal source.

Part II assumes that a function generator or other signal source is available to provide input waveforms. The reader is urged to locate a signal source in order to gain experience under realistic conditions.

NOTE: Part I must be read before proceeding to Part II.

## PART I

Part I assumes that the inputs to the 4094 oscilloscope remain unconnected to outside devices.

- PART I INITIAL SET-UP

#1. Remove diskettes in disk recorders (if applicable) and leave the disk recorder doors open.

#2. Turn the oscilloscope power OFF, POWER button located under the screen.

#3. Turn all knobs on the front of the oscilloscope to the extreme counterclockwise positions.

#4. Place all lever switches to the down position.

Figure 6-1 illustrates the initial set-up positions for the Mainframe and Plug-in controls.

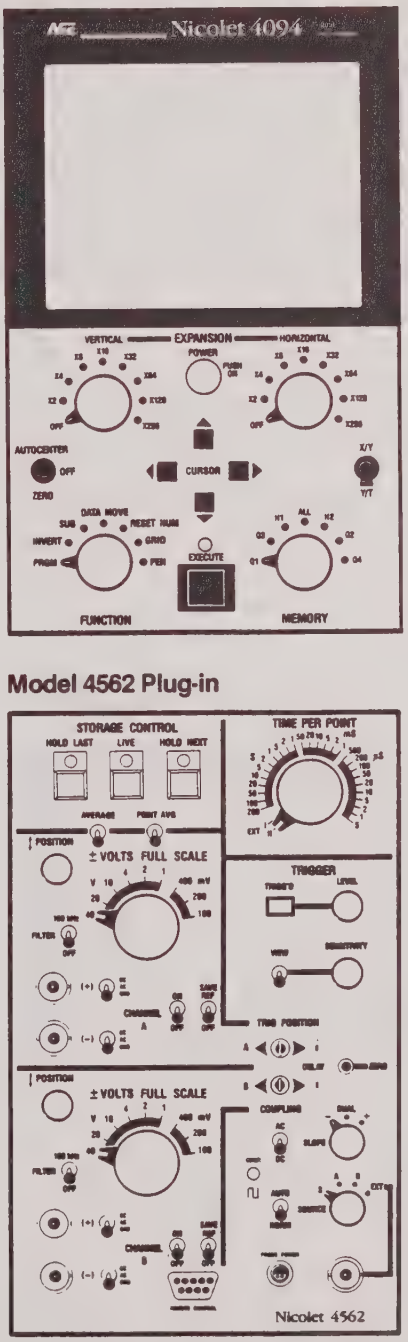



*Figure 6-1*

● OVERVIEW OF CONTROLS

NOTE: Figures 6-2 through 6-10 identify controls which correspond to areas under discussion or require setting selections within the text.

In addition, if the 4094 oscilloscope has two Plug-ins, use only the one on the left side of the oscilloscope for this section (Part I). Leave the other Plug-in with both Channel A and B "ON/OFF" switches in the OFF position.

#1. Apply power to the oscilloscope by pressing in the POWER button located under the screen.

#2. Make the following settings, (Figure 6-2):

a. TIME PER POINT: 10μS
b. CHANNEL A: On
c. TRIGGER: Auto
d. TRIGGER SOURCE: A
e. LIVE: Press.

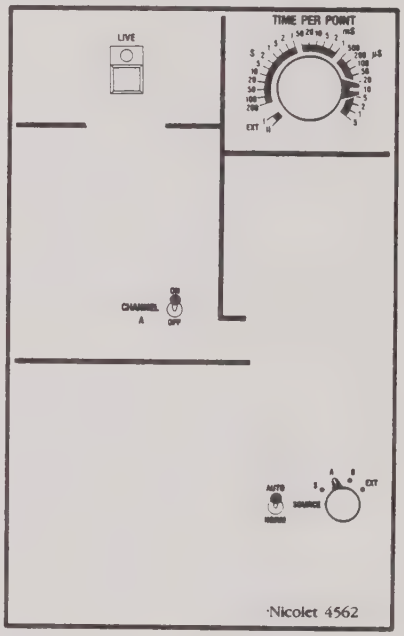



*Figure 6-2*

After the LIVE button has been pressed, the screen will display the horizontal and vertical cursors, and a single line (trace) and crosshair associated with channel A, (Figure 6-3).

NOTE: Since Channel A inputs have been left grounded, the trace will appear as a straight line. The (1A) designation in the lower center of the display screen denotes "Plug-in #1/ Channel A" is being used.

Note that the TRIGGER light is flashing, indicating that sweeps are being made across the display. Each sweep is initiated by a trigger resulting from the AUTO trigger setting.

At this point, it is important to fully understand the display. The vertical and horizontal cursor lines are used to inspect the display for time and voltage.

#3. Manipulate the UP/DOWN and LEFT/ RIGHT cursor controls, Figure 6-3, while observing the time and voltage numerics.

Zero time is located at the left edge of the display. Zero voltage is located at the level of the displayed input from Channel A (ground = zero volts).

The crosshair (also referred to as the "trigger cursor") associated with the Channel A input is always located at zero time, zero voltage. Movement of the horizontal cursor beyond the upper/lower limits of the screen causes them to automatically "wrap-around" and reappear on the opposite side of the display. Movement of the vertical cursor beyond the left/right limits of the screen causes the cursor to stop at the limit. Releasing the CURSOR button and then repressing it

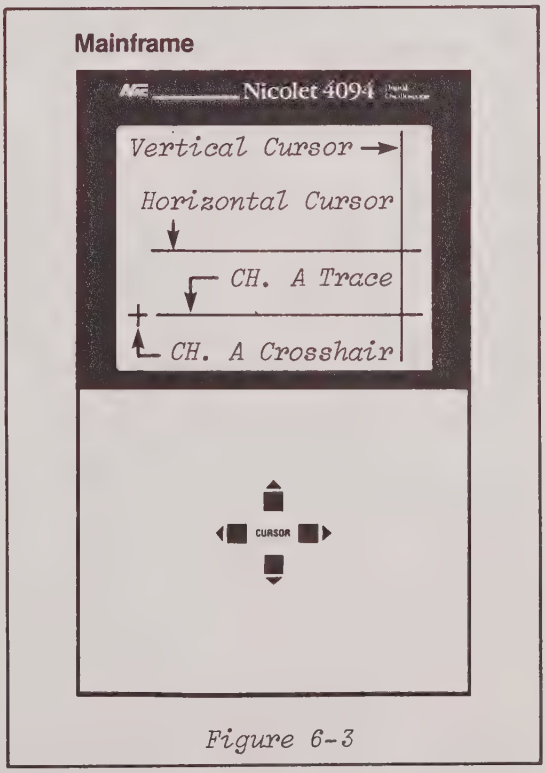



*Figure 6-3*

allows the cursor to "wrap-around" to the opposite side of the screen. This feature can be used to quickly move the cursors from one side to the other.

The most common use of the horizontal and vertical cursors is to indicate the time and voltage of various points on the input waveform. The easiest way to accomplish this is to switch into AUTOCENTER.

#4. Place the AUTOCENTER switch to the Autocenter position, Figure 6-4.

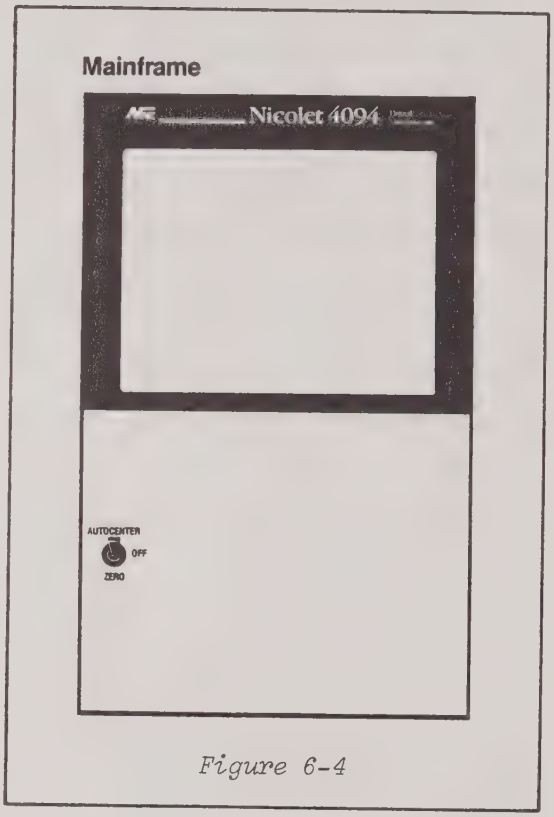



*Figure 6-4*

The horizontal cursor immediately jumps to the intersection point of the vertical cursor and the input waveform.

While in Autocenter, the UP/DOWN cursor controls are inoperative, while the RIGHT/LEFT cursor controls operate as before. The horizontal cursor will always remain located at the intersection of the input waveform and the vertical cursor.

In order to help make the cursors uses even more apparent:

#5. Adjust the Channel A POSITION control (Figure 6-5) until the crosshair, trace, and horizontal cursor are located approximately at the center of the screen.

Note that the voltage numerics are not changed in this process (after the motion is stopped). The POSITION knob affects only the display positioning and does not affect the time or voltage values.

#6. Turn on Channel B, (Figure 6-5).

A new line appears on the screen which represents the Channel B input signal (grounded inputs).

#7. Momentarily tap the LEFT or RIGHT cursor controls.

The crosshair and horizontal cursor shift from the Channel A input trace to the Channel B input trace, and then back again as the cursor control is tapped.

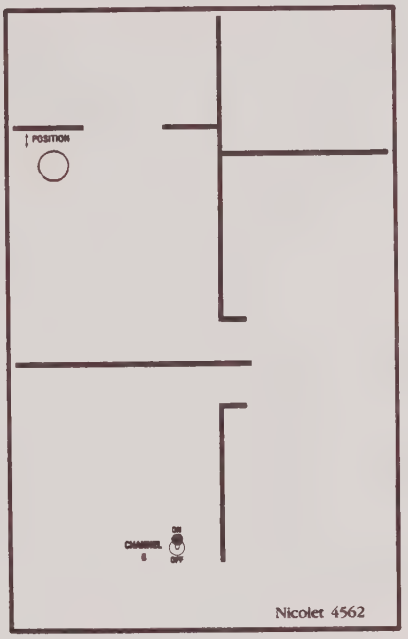



*Figure 6-5*

In order to gain a clearer picture of what is occurring as the cursor control is being tapped:

#8. Place the HORIZONTAL EXPANSION switch to the X256 position, (Figure 6-6).

The two rows of dots indicate the data points on the Channel A and B traces. The display has been symmetrically expanded about the vertical cursor. The crosshairs (trigger cursors) will not be visible unless the expanded portion of the display lies very close to the left edge of the screen.

#9. Momentarily tap the LEFT or RIGHT cursor buttons again.

The vertical cursor moves to the next, closest data point. The input traces appear to move since the display remains centered about the vertical cursor. The horizontal cursor moves to the intersection of the input waveform and the vertical cursor because the AUTOCENTER switch (Step #4) is still in the Autocenter position.

The "1A"/"1B" notations indicate the origins of the data point under inspection. The time and voltage numerics indicate the values associated with each data point coordinate.

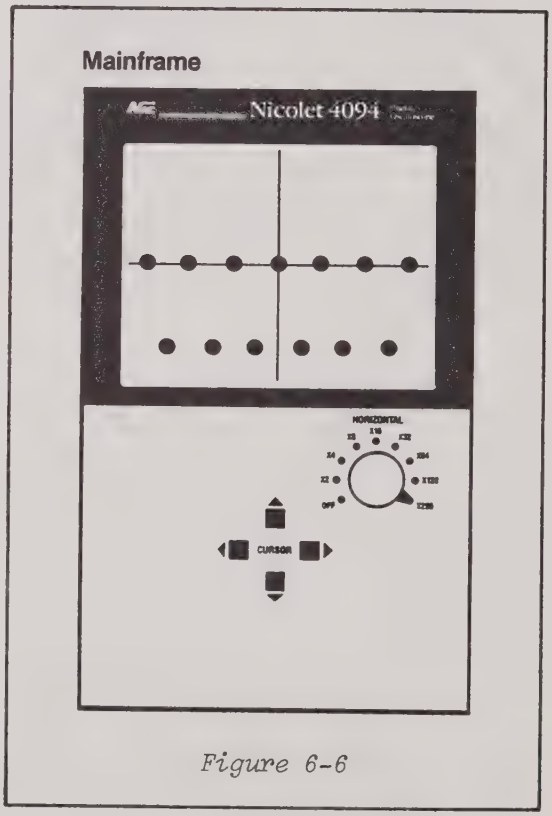



*Figure 6-6*

While the HORIZONTAL EXPANSION switch is still in the X256 position, a couple of interesting display features can be seen.

Channel A and Channel B data points are acquired simultaneously by two separate analog to digital converters. Half of the displayed points belong to Channel A and the other half belong to Channel B. They are displayed in an alternating fashion as though they were taken at different times. However, by stepping the cursor across the screen, point by point, it can be seen that the time numerics are the same for pairs of data points (one from Channel A, one from Channel B) which are acquired at the same time.

Note that the voltage numerics are approximately the same for Channels A and B (since all inputs are grounded) even though they appear vertically separated on the screen. Displayed voltage differences, if any, are due to small amounts of system "noise" inherent in any measuring device.

The time and voltage numerics are always the most important indicators of the waveform characteristics. The common visual judgements made when using analog oscilloscopes are not necessarily valid with digital oscilloscopes.

The last two, but very important, oscilloscope controls to be discussed in Part I are the TIME PER POINT and STORAGE CONTROL switches, (Figure 6-7). Each of these controls are necessary for basic 4094 oscilloscope operation.

The TIME PER POINT switch functions like the time-per-division control on an analog oscilloscope. The TIME PER POINT setting controls sweep speed.

The input to the 4094 oscilloscope is sampled by an analog-to-digital converter and represented on the display as discrete data points.

The time from one point to the next is determined by the TIME PER POINT setting. In order to accurately represent quickly changing input signals, it is necessary to closely space the data points by selecting a small time-per-point. Slow changing inputs do not require high speed sampling and, therefore, larger TIME PER POINT settings are best.

The actual sweep time across the display screen is dependent on the time-per-point and the number of points allotted to the input signal.

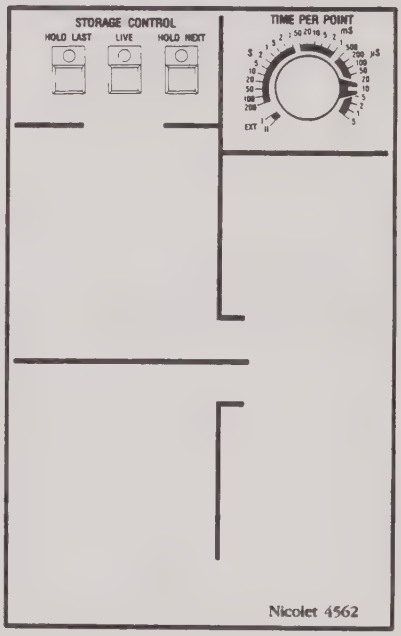



*Figure 6-7*

The 4094 oscilloscope has the capacity to store and display 15,872 data points. The number of points actually used depends on the MEMORY switch, (see the MAINFRAME section of this operation manual). The total number of points selected is also divided among the input channels in use.

To observe the effect that the TIME PER POINT setting has on the sweep speed:

#10. Place the HORIZONTAL EXPANSION switch to the OFF position, (Figure 6-8).

#11. Place the TIME PER POINT switch to the 5mS position, (Figure 6-9).

#12. Press the LIVE button and observe the sweep speed as the trace moves across the screen.

#13. Place the TIME PER POINT switch to either side of the 5mS position and press the LIVE button. Note the difference in the sweep speed.

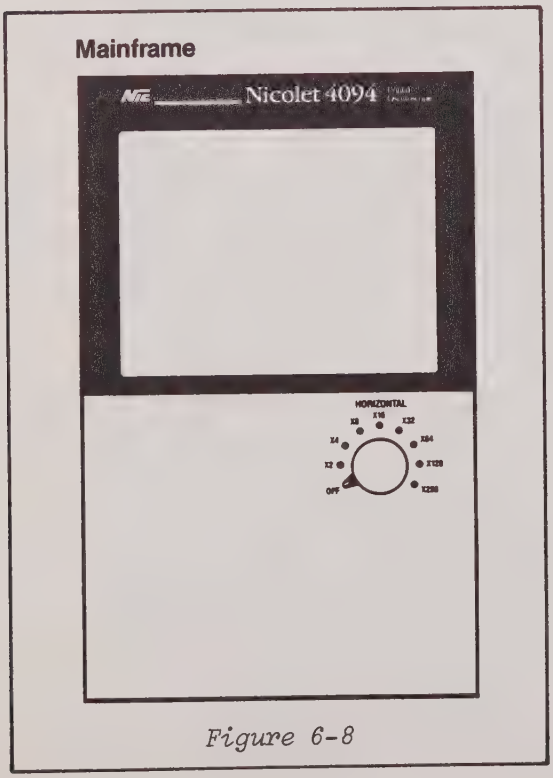



*Figure 6-8*

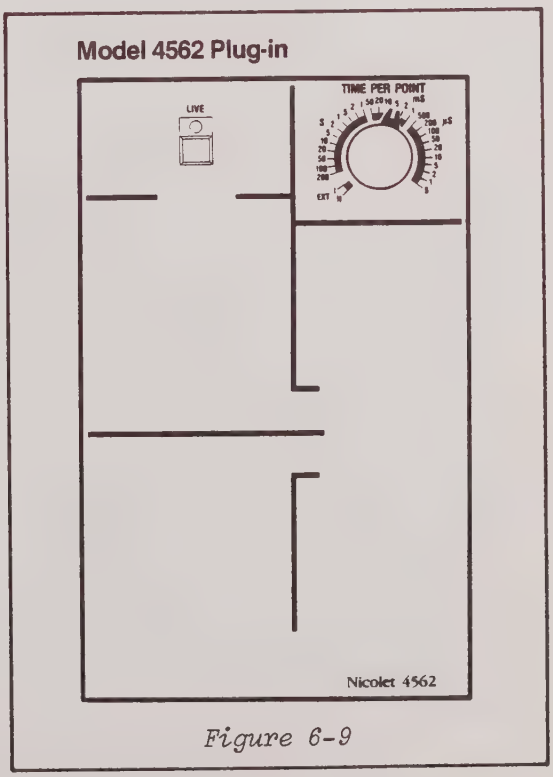



*Figure 6-9*

The STORAGE CONTROL buttons (HOLD LAST, LIVE, and HOLD NEXT) are not complicated and are essential for even the simplest 4094 oscilloscope operation. Definitions of each button are:

- HOLD LAST - Holds the acquired data points in the internal (display) memory of the 4094. HOLD LAST should be pressed if the current display should be saved.
- LIVE - Does not permanently hold any data points in memory. Allows continuous sweeps across the screen (as long as triggers are received), displaying the input signals.

  NOTE: Front panel settings are only acknowledged by the 4094 between each sweep. If a change is made to any front panel control and must be immediately acknowledged by the 4094, the LIVE button must be pressed. Pressing the LIVE button stops sweeps in progress, erases the display, and forces the 4094 to review all front panel settings before continuing. The LIVE button is a very powerful front panel control.
- HOLD NEXT - Holds the data points acquired on the next sweep in the 4094 internal (display) memory. The most common situation is to press LIVE and then HOLD NEXT before a new sweep is started. This sequence will save data acquired during the next sweep in the display memory. Once the data is saved, only the HOLD LAST LED will be illuminated.

#14. Place the TIME PER POINT switch to the 5mS position, (Figure 6-10).

#15. Press the LIVE button.

#16. While in the middle of the sweep, press the HOLD LAST button.

Note that both the LIVE and HOLD LAST LEDs are illuminated. When the sweep is finished, however, only the HOLD LAST button will remain illuminated, the sweeps stop (trigger light stops flashing), and all of the data acquired during the last sweep is saved.

#17. Press the LIVE button.

#18. While in the middle of the sweep, press the HOLD NEXT button.

Note that both the LIVE and HOLD NEXT LEDs are illuminated. In addition, note that the current sweep is not held, but the next sweep is held in the memory. (Watch the TRIGG'D light to see the new sweep being initiated.) The LIVE and HOLD NEXT LEDS turn off and the HOLD LAST LED turns on upon completion of the next sweep.

#19. Press the LIVE button.

Sweeps resume across the screen.

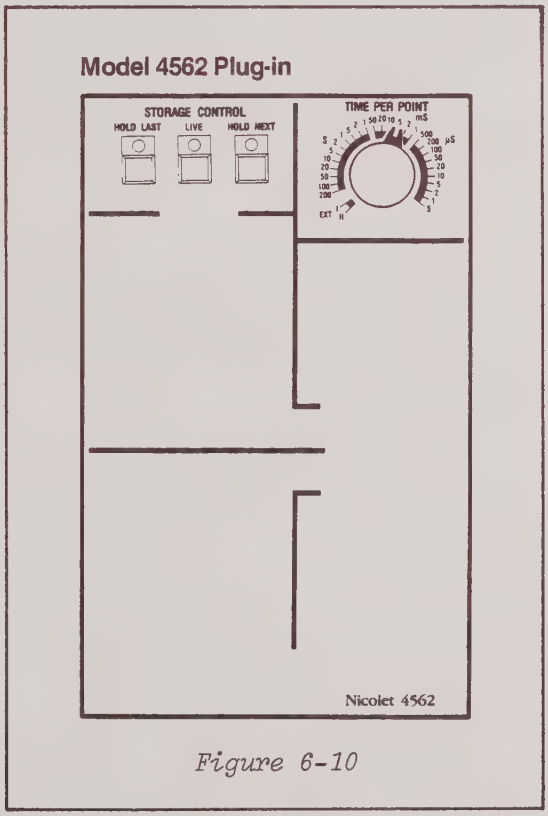



*Figure 6-10*

● ANALOG SCOPE USERS

The most common beginning problem that analog oscilloscope users face when using a 4094 digital oscilloscope is that a display can exist which does not match the input signal. This happens when the data in memory is not replaced by the expected signal.

There are five possible reasons for this, and are listed below in the order of probability:

#1. The 4094 oscilloscope is not in LIVE and therefore will not allow new signals to enter the scope.

#2. Triggering is not occurring. When in doubt, switch into AUTO triggering to ensure that triggering will occur.

#3. Possibly, a sweep has started but is very slow due to a long time-per-point. A time-per-point setting of 200 seconds could make one sweep take longer than five weeks to complete! Turn the TIME PER POINT switch to a faster setting and press the LIVE button.

#4. If only a portion of the display appears "frozen," turn off the SAVE REF switch. A complete explanation of this control is found under the PLUG-INS tab in this manual.

#5. The display may be showing the trigger signal rather than the expected input signal if the trigger VIEW switch is on. A complete description of this switch can be found in Part II of this section and under the PLUG-INS tab in this manual.

## PART II

Part II requires the use of a function generator, or other source of input signals to demonstrate several 4094 oscilloscope controls important for real-life measurements.

NOTE: It is assumed, and recommended, that Part I has been read.

● PART II INITIAL SET-UP

#1. All knobs on the front panels should be in the extreme counterclockwise positions, except -

a. TIME PER POINT: 5mS

b. TRIGGER SOURCE: A

#2. All lever switches should be in the down position, except -

a. AUTOCENTER: On

b. Channel A: On

c. AUTO/NORM: Auto

Figure 6-11 illustrates the initial set-up positions for the Mainframe and Plug-in controls.

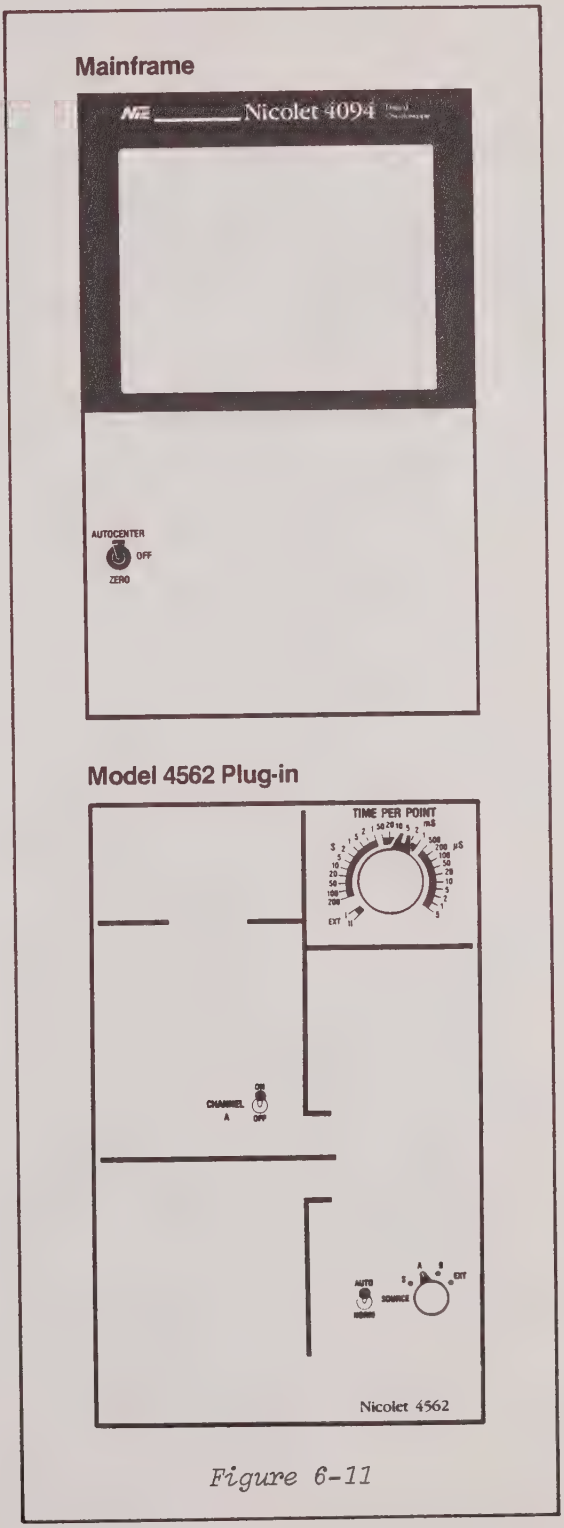



*Figure 6-11*

● OVERVIEW OF CONTROLS

NOTE: Figures 6-11 through 6-17 illustrate the controls which will require repositioning during the following discussions.

#1. Connect the function generator's output to the Channel A (+) input BNC and its sync output to the external (EXT) trigger input BNC, (Figure 6-12).
NOTE: If possible, select a 100 Hz triangle waveform output from the function generator.

#2. Place the Channel A (+) input BNC's switch to the DC position. The "DC" position allows both changing (AC) voltages and non-changing (DC) voltages to enter the oscilloscope. The "AC" position allows only changing voltages to enter the oscilloscope. The "GND" position sets the inputs at zero volts (ground voltage).

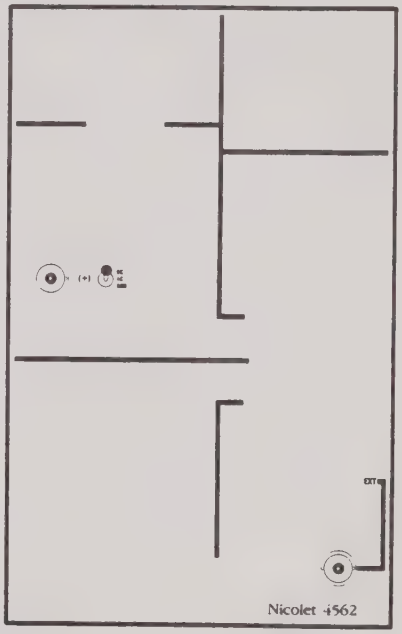



*Figure 6-12*

At this point, the oscilloscope's screen will display the waveform coming from the function generator.

If necessary, adjust the Channel A POSITION control (Figure 6-13) so that the input signal appears approximately in the middle of the screen.

#3. Adjust the ±VOLTS FULL SCALE switch (Figure 6-13) until the waveform's amplitude is as large as possible without exceeding the screen's vertical limits. The ±VOLTS FULL SCALE switch sets the maximum allowable input voltage which can be viewed without being too large for the display.

#4. Adjust the TIME PER POINT switch until the waveform is easily seen. A function generator setting of approximately 100 Hz will be sufficient for this section.

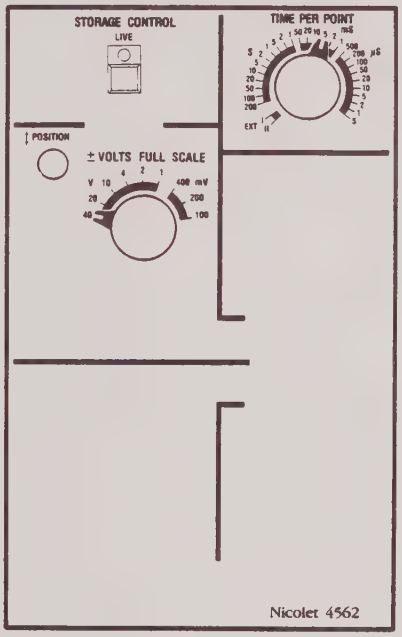



*Figure 6-13*

NOTE: Press the LIVE button after each new TIME PER POINT setting is made, forcing the 4094 to acknowledge each new setting. It is not necessary, however, to press the LIVE button if fast TIME PER POINT settings are selected, causing rapid sweeps. This is because the 4094 automatically verifies all of the front panel control positions at the beginning of each new sweep.

An acceptable TIME PER POINT setting allows the user to see necessary details in the input waveform. There are pitfalls to be avoided when choosing the correct TIME PER POINT. The following exercise will show the ease with which TIME PER POINT settings can be made correctly.

#5. Place the TIME PER POINT switch to the extreme clockwise (.5μS) position while observing the display. Shorter times between sample points will make the waveform to appear stretched out.

#6. Move the TIME PER POINT switch one step at a time in the counterclockwise direction. The longer the times between sample points, the more compressed the waveform appears. When the display of the waveform becomes so compressed that the actual wave shape cannot be discerned, stop moving the TIME PER POINT switch. Are the data points now too far apart to be useful?

#7. Turn the HORIZONTAL EXPANSION switch until the waveform can be easily seen. There are obviously more than enough points to define the waveform. Without HORIZONTAL EXPANSION, the confused appearance of the waveform is due to visual aliasing. In other words, the human eye has difficulty seeing the correct dot to dot alignment.

#8. Move the TIME PER POINT switch, one step at a time, in the counterclockwise direction. Wait long enough between switch settings to see the display actually change to reflect the new data point spacing. Each time the waveform becomes difficult to see, increase the HORIZONTAL EXPANSION. At some point, the waveform is totally lost and can not be retrieved by expanding. The TIME PER POINT setting is now too slow and the display does not show worthwhile information. This situation is called sample time aliasing.

#9. Place the HORIZONTAL EXPANSION switch to the OFF position in order to view the pattern of data points due to visual aliasing.

#10. Turn the TIME PER POINT switch even further in the counter-clockwise direction. This may result in recognizable patterns to appear out of the confused "jumble" of data points. However, these patterns do not accurately represent the input signals since the sampling rate is much too slow.

How is the best TIME PER POINT setting selected? Always begin the search at the fastest TIME PER POINT setting and slowly work toward the slower settings. In this manner it is easy to avoid accidentally stopping on a TIME PER POINT which is too slow for the input. Another method is to set the TIME PER POINT to be equal to, or less than, 1/10 of the input waveform period -

$$\text{period} = \frac{1}{\text{freq.(Hz)}}$$

A quick mental approximation is usually good enough to avoid undersirable aliasing effects.

The final important area to be covered in Part II is triggering. Proper triggering is necessary in virtually every measuring situation.

In many cases, important data will be lost if trigger controls are set improperly.

Triggering is a widely used term which denotes an internal decision within the oscilloscope to start a new sweep. All sweeps must be initiated by a trigger. The decision to sweep is usually synchronized with the input signal. Trigger location with respect to the display, trigger sensitivity, and trigger level are all used to select triggers which aid waveform measurements. Initiating triggers at the proper time is often the most critical part of an experimental oscilloscope setup.

The AUTO triggering used in the preceding descriptions assures that a trigger will be received so that each new sweep can start. However, unless triggering is synchronized with the input signal, the displayed waveform will "free run" across the screen. The trigger controls covered here allow the user to synchronize the triggering to the input signal.

#11. Place the trigger VIEW switch to the VIEW position, (Figure 6-14).

#12. Make sure that the trigger SOURCE switch is still set at "A."

#13. Press the LIVE button.

The trigger VIEW display makes trigger adjustments very easy and accurate. The traditional guesswork used to set analog oscilloscope trigger controls is not necessary. The right side of the trigger VIEW display shows the input signal used to synchronize triggering. The input signal shown is dependent on the position of the trigger SOURCE switch, (Figure 6-14).

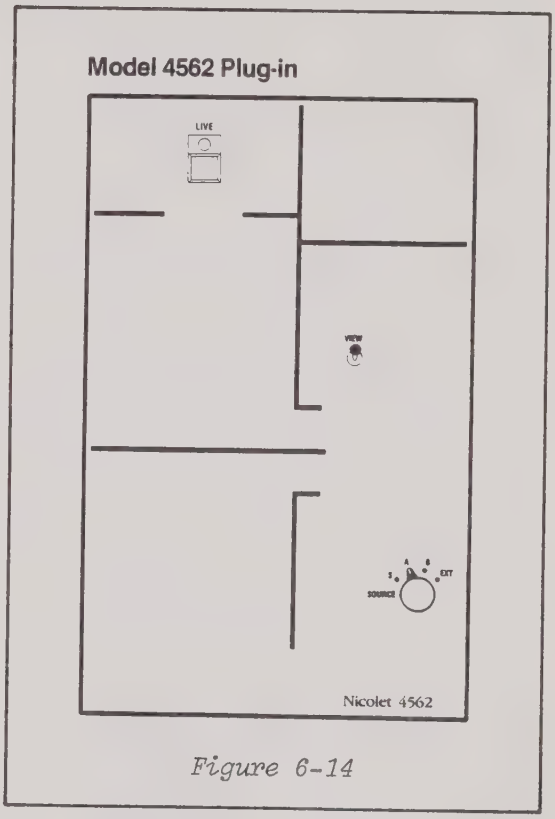



*Figure 6-14*

#14. Rotate the trigger SOURCE switch to the EXT position and then back to "A."

Observe the display to see the channel A and external trigger inputs available for trigger synchronization (assuming that the EXT (external) trigger input has been connected to the function generator).

#15. Adjust the trigger LEVEL control (Figure 6-15) until the two horizontal lines intersect with the waveform.

Note that triggering is now synchronized and the "free-running" waveform has stabilized.

#16. Adjust the trigger SENSITIVITY control (Figure 6-15) while watching for the waveform to "free-run."

As long as both horizontal lines intersect the waveform, triggers will be synchronized with the input.

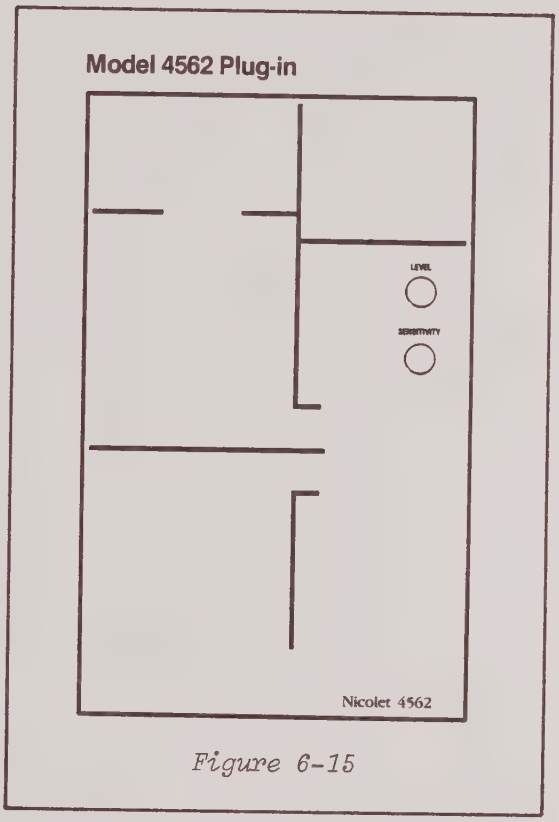



*Figure 6-15*

A synchronized trigger will occur within the oscilloscope when the input voltage crosses the two horizontal lines shown in trigger VIEW, (Figure 6-16).

An increased trigger LEVEL will mean that the input signal will need larger voltages to produce a trigger. A wider gap between the lines decreases the sensitivity, making the trigger circuitry less susceptible to random low amplitude noise. With AUTOCENTER switched on, the voltage numerics will show the actual voltage level of each horizontal line when the horizontal cursor is made to align with them (move the vertical cursor if necessary).

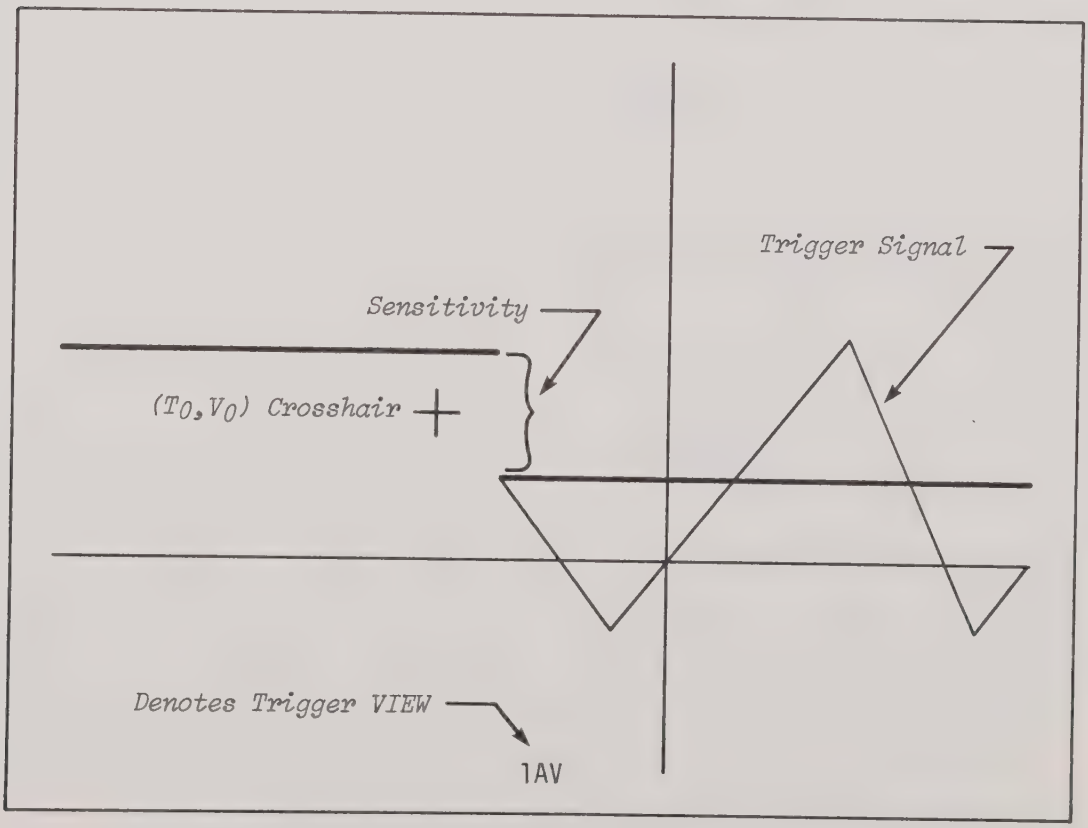



*Figure 6-16*

#17. Place the trigger SLOPE switch to the "DUAL" and then "+" positions while observing the display, (Figure 6-17).

The trigger SLOPE switch determines whether the triggers take place on rising (+) slopes, or falling (-) slopes of the waveform.

The DUAL setting allows a trigger to occur on whichever slope appears first, (+) or (-), and only requires the waveform to cross one of the horizontal lines. DUAL is useful for triggering on single pulses when the correct slope is not known. When the input waveform is repetitive, DUAL cannot be used since the displayed waveform will "free-run."

#18. Switch from AUTO triggering to NORM triggering and then back again to AUTO, (Figure 6-17).

Note that synchronization is not lost and the trigger light remains flashing.

AUTO triggering forces a trigger to occur even if the trigger controls are misadjusted and synchronization is not possible. NORM triggering does not force triggers to occur and, therefore, the correct trigger LEVEL and SENSITIVITY must be selected.

AUTO triggering is commonly used during oscilloscope setup. Once the correct front panel settings are selected it is usually desirable to switch away from AUTO. Transient pulses can only be captured while in NORM since only one sweep is required.

#19. Turn trigger VIEW off, (switch down position), Figure 6-17.

The input signal is now easily viewed.

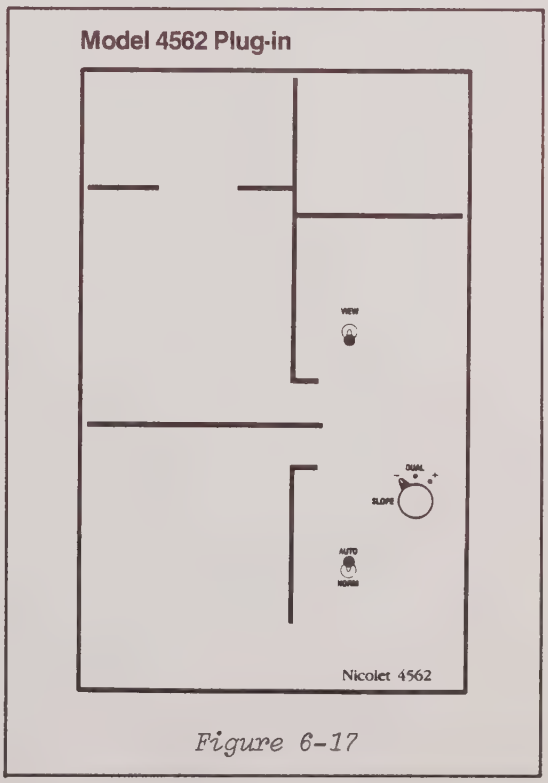



*Figure 6-17*

## SUMMARY

Parts I and II have covered the essential 4094 front panel controls which are necessary for virtually any standard measurement. Many controls and functions remain which have not been discussed and which give power and versatility to the 4094. In depth explanations of all controls can be found in the appropriate sections of this manual.

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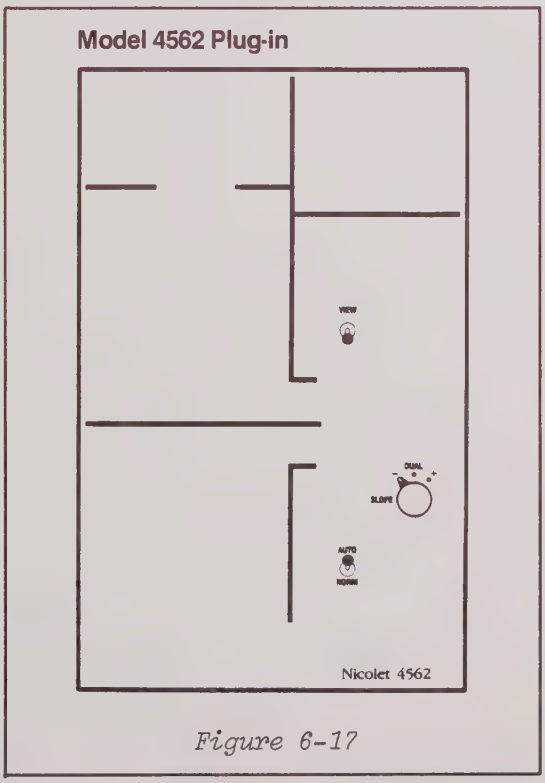
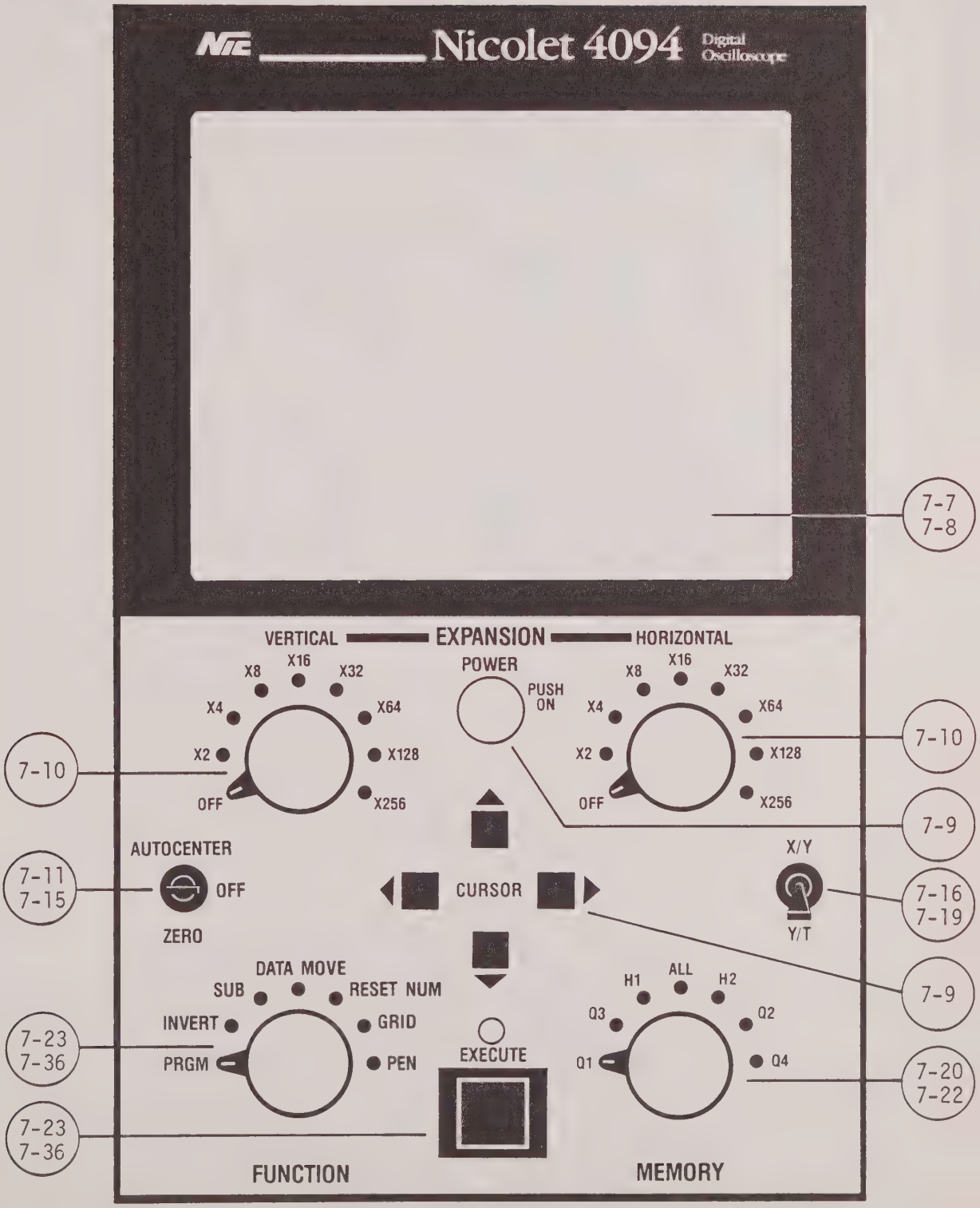



*Figure 6-17*

## SUMMARY

Parts I and II have covered the essential 4094 front panel controls which are necessary for virtually any standard measurement. Many controls and functions remain which have not been discussed and which give power and versatility to the 4094. In depth explanations of all controls can be found in the appropriate sections of this manual.

# Mainframe


Nicolet 4094
Digital Oscilloscope
VERTICAL
EXPANSION
HORIZONTAL
POWER
PUSH ON
X8
X16
X32
X4
X64
X2
X128
OFF
X256
AUTOCENTER
OFF
ZERO
CURSOR
X/Y
Y/T
DATA MOVE
SUB
RESET NUM
INVERT
GRID
PRGM
PEN
EXECUTE
H1
ALL
H2
Q3
Q2
Q1
Q4
FUNCTION
MEMORY
7-7
7-8
7-10
7-10
7-9
7-11
7-15
7-16
7-19
7-9
7-23
7-36
7-20
7-22
7-23
7-36

## INTRODUCTION

The Mainframe includes a display memory, display screen and various controls to manipulate the display screen components.

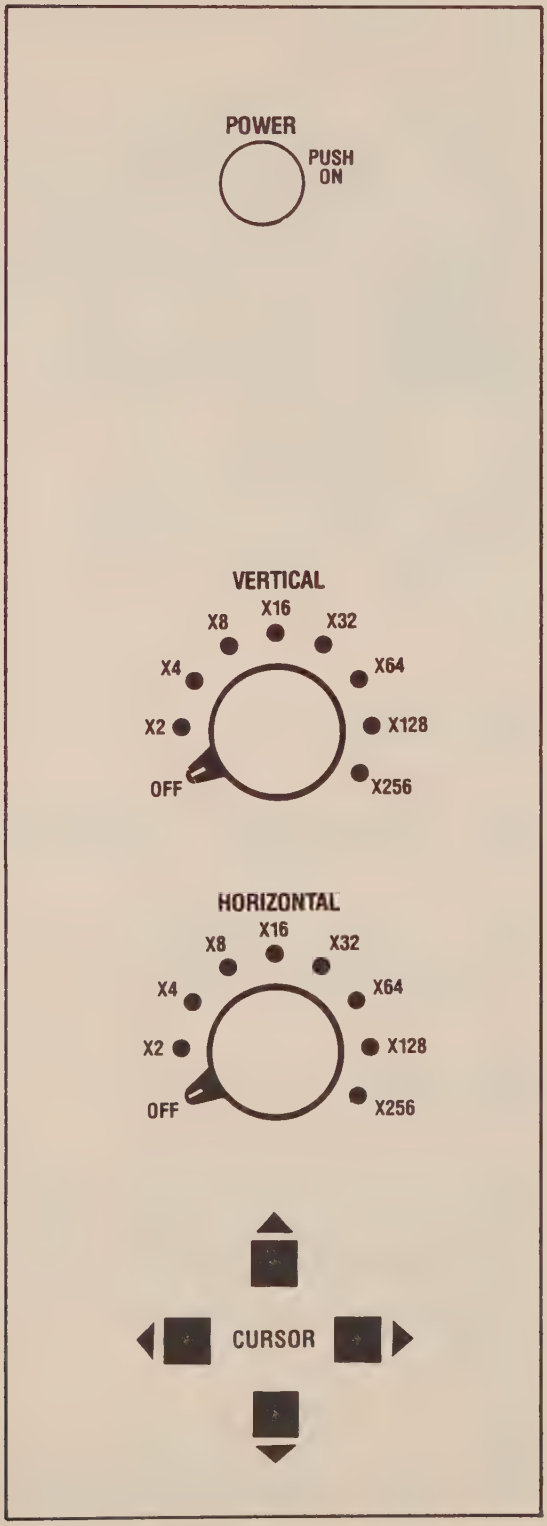
Features include -

- Horizontal expansion of up to X256.
- Vertical expansion of up to X256.
- Autocentering.
- Choice of XY or YT displays.
- 15,872 ($2^{14}$ - 512) word display memory which can be left intact or divided into halves or quarters.
- Multiple function abilities; including arithmetic manipulations, electronic graticule, and pen recording outputs.

NOTE: In order to simplify the following discussions within this section of the manual, the number of addresses (words) in the memory will be rounded off as follows -

- 15,872 words = (16K)
- 7,936 words = (8K)
- 3,968 words = (4K)

► IMPORTANT: The term "Hold mode" will be used in the following discussions to signify that the Plug-in is in the Hold Last mode. (The LIVE and HOLD NEXT LEDs are off and only the HOLD LAST LED is illuminated.)




## POWER SWITCH OPERATOR

Applies line power to the 4094 when pushed in. Removes power when pulled out.

> WARNING: Before applying power to this instrument, refer to the *Receiving & Pwr Req's* tab, page 5-2.

## VERTICAL EXPANSION SWITCH

Vertically expands the displayed data group by up to 256 times.

## HORIZONTAL EXPANSION SWITCH

Horizontally expands the displayed data group by up to 256 times

## CURSOR BUTTONS

Reposition the displayed data group and/or Mainframe cursors on the display screen.

## AUTOCENTER SWITCH

- AUTOCENTER - Data group passes through screen center when vertical and horizontal expansions are on. When the Expansion switches are off, the horizontal cursor intersects the vertical cursor at the coordinate decoded by the numerics display.
- OFF - Turns Autocenter off.
- ZERO - Repositions Mainframe's horizontal cursor to zero volts coordinate.

## XY-YT SWITCH

- XY - One data group is displayed as a function of another.
- YT - Displays data groups as voltage functions of time.

## MEMORY SWITCH

Determines the length of record for the data group to be acquired. Also determines where a waveform will be stored or which data group(s) will be displayed.

- ALL - 15,872 (16K) words.
- H1 & H2 - 7,936 (8K) words, each.
- Q1 - Q4 - 3,968 (4K) words, each.

## FUNCTION SWITCH

The EXECUTE button must be pressed, unless otherwise noted, before the selected function will be performed.

- PRGM - Activates the one-button functions, as selected through recall, from the Program Diskettes.
- INVERT - Multiplies displayed data by (-1).
- SUB - Subtracts one data group from another. Can also be used to "add" two data groups by inverting one of the groups and then subtracting.
- DATA MOVE - Vertically repositions a selected data point to the level of the horizontal cursor. All other data points in the selected data group shift by the same amount.
- RESET NUM - Resets the voltage-time origins (0,0) to any point on the screen selected by the intersection of the vertical and horizontal cursor.
- GRID - Allows an electronic graticule to appear on the screen. Does not have to be Executed.
- PEN - Initiates a pen recording output.

## DISPLAY COMPONENTS

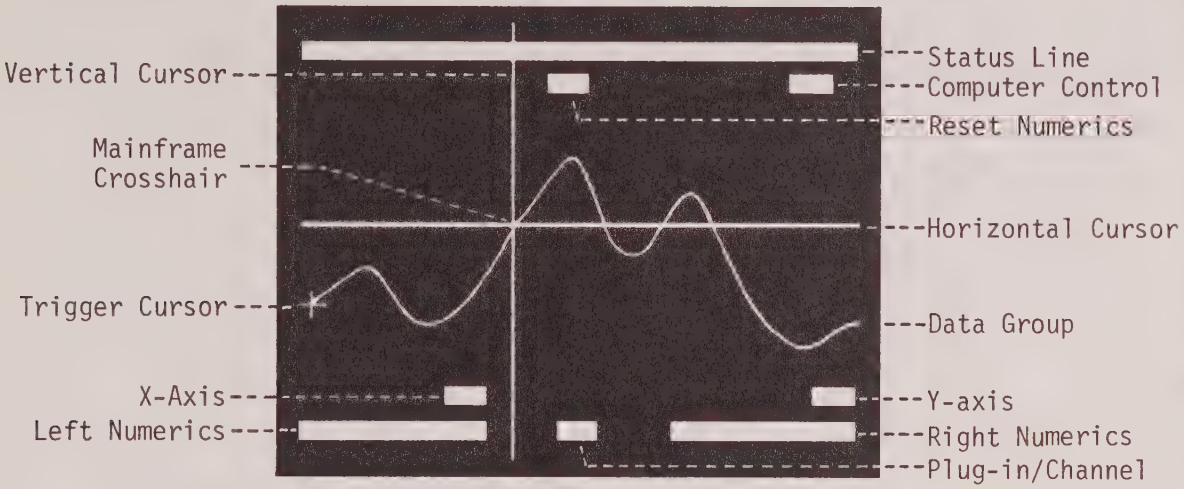



*Figure 7-1*

● STATUS LINE

Function of the Disk Programs. See *Disk Programs* tab.

● RESET NUMERICS INDICATOR

Indicates new (0,0) origins have been selected. See page 7-29.

● DATA GROUP

The displayed input signal (waveform).

● TRIGGER CURSOR

Identifies the time and voltage (0,0) origins. See *Plug-ins* tab, page 8-38.

● X-AXIS & Y-AXIS IDENTIFIERS

Identify which Plug-in/Channel acquired the displayed voltage values. (Appear in the XY mode only.)

● COMPUTER CONTROL INDICATOR

Indicates the front panel controls are inhibited. See *Input/Output* tab, page 13-1 and *Disk Programs* tab, page 14-7.

● LEFT NUMERICS

- YT Mode - Time coordinates.
- XY Mode - X-axis' voltage.

● RIGHT NUMERICS

- YT Mode - Voltage coordinates.
- XY Mode - Y-axis' voltage.
- Trigger View Mode - Upper/lower threshold voltages. See *Plug-ins* tab, page 8-33.

● PLUG-IN/CHANNEL IDENTIFIER

Identifies which Plug-in/Channel acquired the signal. In addition -

- 1AR = Plug-in 1/Channel A; Save Reference mode selected.
- 1AV = Plug-in 1/Channel A; View mode selected.
- 1EV = Plug-in 1, External trigger and View modes selected.

● VERTICAL & HORIZONTAL CURSORS

The vertical (time) and horizontal (voltage) cursors form the Mainframe's crosshair.

## NUMERICS SYMBOLOGY

Table 7-1 tabulates the power of ten symbols used to describe the voltage and time numerics readouts.

| SYMBOLS | POWER FACTORS |
|---|---|
| p = pico | $10^{-12}$ |
| n = nano | $10^{-9}$ |
| u = micro | $10^{-6}$ |
| m = milli | $10^{-3}$ |
| "blank" | $10^{0}$ |
| k = kilo | $10^{3}$ |
| M = mega | $10^{6}$ |
| G = giga | $10^{9}$ |
| T = tera | $10^{12}$ |
| P = pata | $10^{15}$ |
| E = exa | $10^{18}$ |
| ? = ** | $10^{21}$ |
| ! = ** | $10^{24}$ |

*Table 7-1*

** NOTE: Power factors above $10^{18}$ are not industry standards. The symbols (?) and (!) have been selected to call attention to the operator that extreme numbers are being used.

## POWER OPERATOR

> WARNING: Before applying power to this instrument, refer to *Receiving & Pwr Req's* tab, page 5-2.

Pressing the POWER operator applies power to the switching power supply. Pulling the operator out removes the power.

The magnetic power switch, mounted inside and toward the rear of the Mainframe, is designed to remove power from the switching power supply when a current overload occurs.

Power can be reapplied, after the proper current level has been restored, by cycling the POWER operator.

The switching power supply is also guarded by a 5 amp fuse mounted on the supply board.

> CAUTION: Remove all power from the oscilloscope before replacing the fuse.

## CURSOR BUTTONS

The CURSOR buttons manipulate the Mainframe's vertical and horizontal cursors. They also manipulate the display data group, depending upon whether or not Autocenter and/or Display Expansion are being used. Refer to *Autocenter Switch*, page 7-11.

## EXPANSION SWITCHES

The displayed data group can be symmetrically expanded up to 256 times about the cursors.

● Horizontal Expansion Switch
The vertical cursor and data point it is intersecting reposition to screen center. All other data points reposition by the same amount, symmetrically expanding about the vertical cursor.

● Vertical Expansion Switch
The horizontal cursor repositions to screen center. Vertical expansion is symmetrical about the horizontal cursor. To vertically reposition data, use the up/down cursor controls.

NOTE: Switching on Autocenter will automatically reposition data to intersect the vertical and horizontal cursors, but will inhibit the use of the up/down cursor controls (see Page 7-11).

*EXAMPLE #7-1*

*Figure 7-2: An unexpanded display.*

*Figure 7-3: After a (X4) horizontal expansion.*

*Figure 7-4: After a (X4) vertical expansion.*

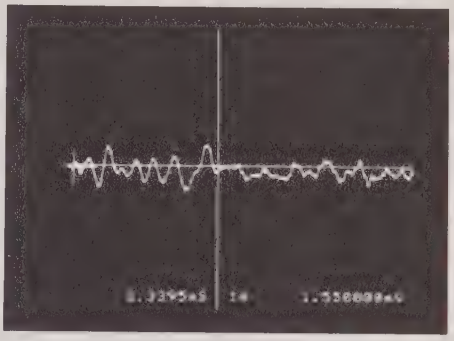


*Figure 7-2*

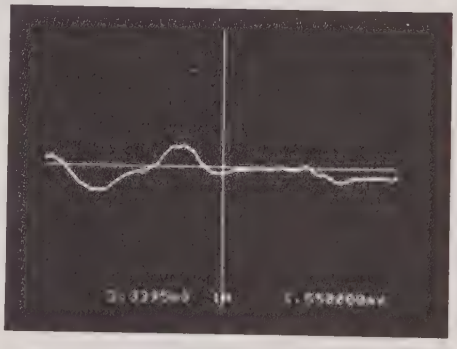


*Figure 7-3*

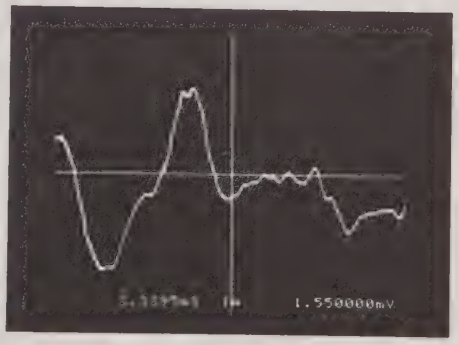



*Figure 7-4*

## AUTOCENTER SWITCH

The AUTOCENTER switch enables the operator to manipulate the display elements in various combinations according to the position selected.

- ZERO

The Mainframe's horizontal cursor repositions to the zero volts location.

The position is spring loaded, automatically returning to the "OFF" position when released.

- OFF

Turns off the Autocenter mode, enabling the operator to manipulate the display elements individually with the CURSOR buttons.

Which of the elements will be affected depends upon the positions selected on the EXPANSION switches. See Table 7-2 (Autocenter OFF).

| EXPANSION SWITCHES | | CURSOR BUTTONS | |
|---|---|---|---|
| HORIZONTAL | VERTICAL | LEFT - RIGHT | UP - DOWN |
| OFF | OFF | *Vertical Cursor* | *Horizontal Cursor* |
| OFF | ON | *Vertical Cursor* | *Data Group* |
| ON | OFF | *Data Group* | *Horizontal Cursor* |
| ON | ON | *Data Group* | *Data group* |

*Table 7-2 (Autocenter OFF)*

● AUTOCENTER

The Mainframe's crosshair superimposes over the data point intersected by the vertical cursor.

In Horizontal expansion mode, the data group passes through screen center when the left or right CURSOR buttons are pressed.

Autocenter is also used when displaying multiple data groups, enabling the operator to determine which data point corresponds with the numerics' readout. The Plug-in/Channel numerics indicate which Plug-in and channel acquired the displayed data point being inspected. (i.e., 1A = Plug-in #1/Channel A.)

The operator can manipulate the display screen elements in various combinations by pressing the CURSOR buttons. Which of the elements will be affected depends upon the positions selected on the EXPANSION switches. See Table 7-3 (Autocenter ON).

| EXPANSION SWITCHES | | LEFT - RIGHT CURSOR BUTTONS |
|---|---|---|
| HORIZONTAL | VERTICAL | |
| OFF | OFF | *Horizontal and Vertical Cursors* |
| OFF | ON | *Vertical Cursor* |
| ON | OFF | *Horizontal Cursor and Data Group* |
| ON | ON | *Data Group* |

*Table 7-3 (Autocenter ON)*

● Autocenter & Expansion Combined

The combination of Autocenter and both vertical and horizontal expansion is the most commonly used form of display expansion.

This mode of operation allows a specific area of interest to be repositioned to screen center for close inspection. The data group passes through screen center when the left or right CURSOR buttons are pressed.

#1. Position the vertical cursor over the area of interest.

#2. AUTOCENTER: On
   a. Mainframe's crosshair superimposes over data point intersected by the vertical cursor.

#3. Place display into both vertical and horizontal expansion.
   a. Crosshair and area of interest reposition to screen center.

#4. Press left or right CURSOR button.
   a. Data group passes through screen center.

*EXAMPLE #7-2*

*Figure 7-5: Unexpanded display. The vertical cursor is positioned over the area of interest.*

*Figure 7-6: AUTOCENTER switch is turned on. The Mainframe's crosshair superimposes over the data point intersected by the vertical cursor.*

*Figure 7-7: Vertical and horizontal expansion applied. The crosshair and area of interest reposition to screen center.*

*Pressing either the left or right CURSOR buttons causes the data group to pass through screen center.*

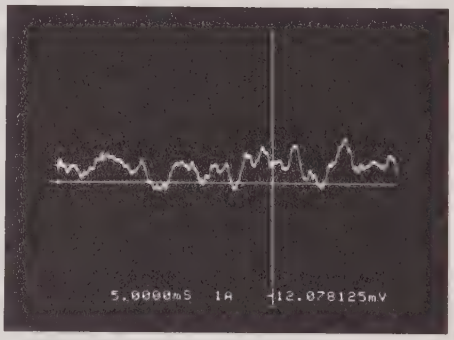



*Figure 7-5*

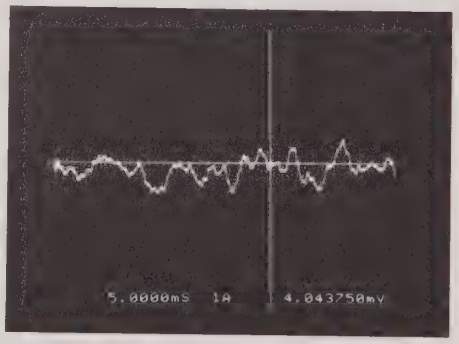



*Figure 7-6*

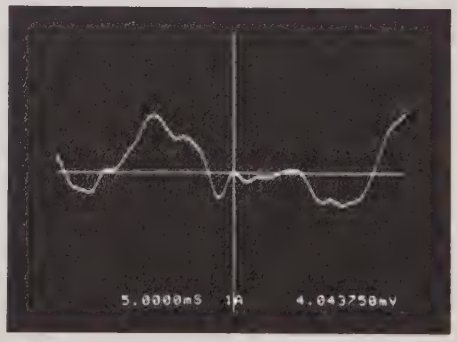



*Figure 7-7*

● Multiple Data Group Displays

The numerics correspond to the intersection of the vertical and horizontal cursor.

Turning the Autocenter mode on superimposes the Mainframe's crosshair over the data point being inspected. The crosshair alternates between the data groups when either the left or right CURSOR button is pressed.

*EXAMPLE #7-3*

*Figure 7-8: Display with two superimposed data groups and Autocenter turned off. The voltage numerics correspond to the position of the horizontal cursor and are not related to either data group.*

*Figure 7-9: The same display, but with the AUTOCENTER switch turned on. The Mainframe's crosshair superimposes over the data point being inspected The Plug-in/Channel numerics indicate which Plug-in/Channel acquired the data point being inspected.*

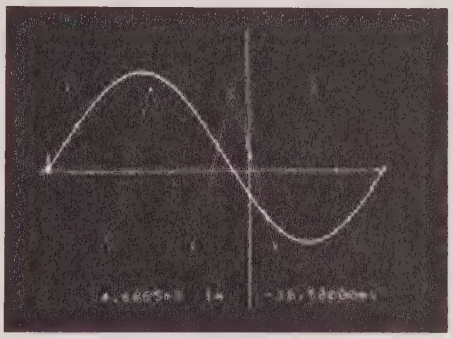


*Figure 7-8*

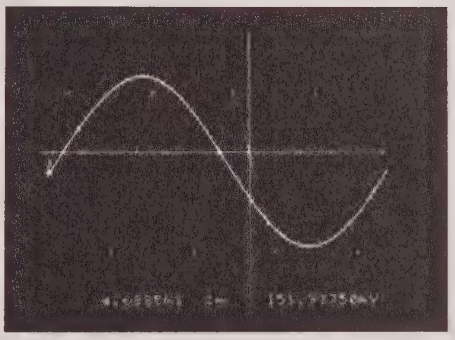


*Figure 7-9*

## XY-YT SWITCH

● YT

Displays data groups as voltage functions of time.

The left numerics (time) and right numerics (voltage) reflect the values at the intersection of the vertical and horizontal cursors. With the AUTOCENTER switch on, this intersection will coincide with a specific displayed data point.

● XY

Displays one data group's voltage values plotted as a function of another.

The left numerics (X-axis' voltage) and right numerics (Y-axis' voltage) reflect the values measured at the intersection of the vertical and horizontal cursors. (With AUTOCENTER on, this intersection will coincide with a specific data point.) The X-axis' Identifier is displayed over the Left Numerics and the Y-axis' Identifier over the Right Numerics.

Store the X-axis' data group in either the Q1, Q2, or H2 subsections of the display memory. The Y-axis' data group must be stored in the corresponding subsections of either Q3, Q4, or H2.

For example, if the X-axis' data group is stored in subsection Q1, then the Y-axis' data group must be stored in subsection Q3. Placing the MEMORY switch to the H1 position, after both data groups have been stored, produces the XY display.

Table 7-4 summarizes which subsections the respective data groups must be stored in, and the MEMORY switch position required for the XY display.

| MEMORY SWITCH POSITION REQUIRED FOR XY DISPLAYS | AXIS Vs SUBSECTION | |
|---|---|---|
| | X-axis | Y-axis |
| H1 | *Q1* | *Q3* |
| H2 | *Q2* | *Q4* |
| ALL | *H1* | *H2* |

*Table 7-4*

NOTE: The AUTOCENTER switch must be turned on to select a specific data point for inspection. The Mainframe's crosshair will superimpose over the selected data point. If both EXPANSION switches are turned off, the crosshair will trace the XY display when either the left or right CURSOR buttons are pressed. Placing the display into horizontal expansion will slow the rate of movement if it is too fast to control.

The XY display can be selected to pass through screen center by placing the display into both horizontal and vertical expansion.

An XY display can also be obtained in the Live move of operation when acquiring signals with two channels. Input the X-axis' signal to channel A and the Y-axis' signal to channel B.

*EXAMPLE #7-4*

*Figure 7-10: Two data groups displayed in the YT mode.*

*Figure 7-11: The same two data groups displayed in the XY mode.*

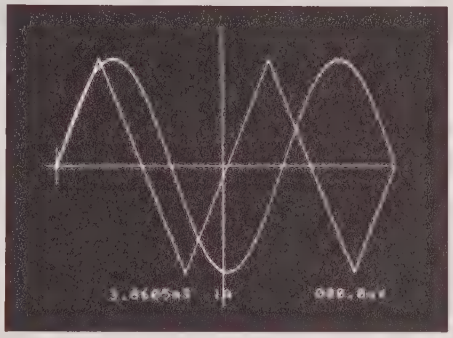


*Figure 7-10*

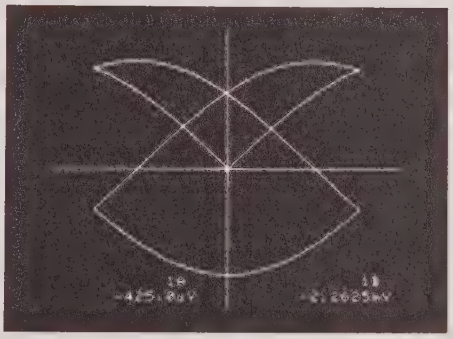


*Figure 7-11*

● XY Display Procedure

#1. Store the X-axis' data group in either subsection Q1, Q2, or H1.

#2. Store the Y-axis' data group in the associated subsection of either Q3, Q4, or H2.

#3. Display both data groups by selecting the appropriate position on the MEMORY switch.

#4. XY-YT switch: XY

#5. AUTOCENTER switch: On

#6. EXPANSION switches: Both "ON" if XY display is to pass through screen center. If crosshair is to trace the XY display, horizontal expansion will slow the rate of movement.

#7. Select the data point to be inspected by pressing either the left or right CURSOR buttons.
   a. Left Numerics = X-axis volts
   b. Right Numerics = Y-axis volts

NOTE: In "dual channel" operation and with the MEMORY switch in either the ALL, H1, or H2 position, signals acquired by channels A and B are automatically routed to the correct subsections for an XY display.

Table 7-5 summerizes which subsections the respective signals will be routed to according to the position selected on the MEMORY switch.

| DUAL CHANNEL OPERATION | | |
|---|---|---|
| MEMORY SWITCH | CHANNEL A | CHANNEL B |
| ALL | *H1* | *H2* |
| H1 | *Q1* | *Q3* |
| H2 | *Q2* | *Q4* |

*Table 7-5*

● Rotating an XY Display

If the X-axis' data group was erroneously stored in the Y-axis' subsection, and vice versa, an incorrect XY display will occur. The error can be quickly corrected, without have to perform the measurements over again, by following the appropriate procedure listed below.

| ROTATING Q1 AND Q3 | ROTATING H1 AND H2 | ROTATING Q2 AND Q4 |
|---|---|---|
| #1. XY/YT: YT | #1. XY/YT: YT | #1. XY/YT: YT |
| #2. MEMORY: Q1 | #2. MEMORY: H1 | #2. MEMORY: Q2 |
| #3. Execute SUB | #3. Execute SUB | #3. Execute SUB |
| #4. MEMORY: Q3 | #4. MEMORY: H2 | #4. MEMORY: Q4 |
| #5. Execute SUB | #5. Execute SUB | #5. Execute SUB |
| #6. MEMORY: Q1 | #6. MEMORY: H1 | #6. MEMORY: Q2 |
| #7. Execute SUB | #7. Execute SUB | #7. Execute SUB |
| #8. MEMORY: H1 | #8. MEMORY: ALL | #8. MEMORY: H2 |
| #9. Execute INVERT | #9. Execute INVERT | #9. Execute INVERT |
| #10. XY/YT: XY | #10. XY/YT: XY | #10. XY/YT: XY |

## MEMORY SWITCH

The display memory contains (16K) words of memory which can be left intact or be divided into either halves or quarters.

Typically, the display memory will be left intact, recording a single input signal with all (16K) words of memory. This will provide the highest detailed reproduction of the input signal.

However, dividing the memory into subsections allows several input signals to be compared or arithmetically manipulated.

*EXAMPLE #7-5*

*The following figures will be used to represent intact and divided memories for the remaining examples.*

*Figure 7-12: Intact memory of (16K) words. All data points displayed.*

*Figure 7-13: Memory divided into two (8K) word subsections. Every other data point is displayed.*

*Figure 7-14: Memory divided into four (4K) word subsections. Every fourth data point is displayed.*




*Figure 7-12*

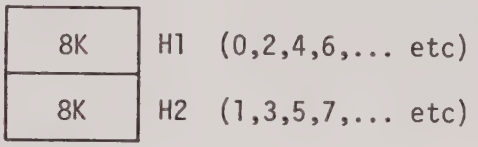



*Figure 7-13*

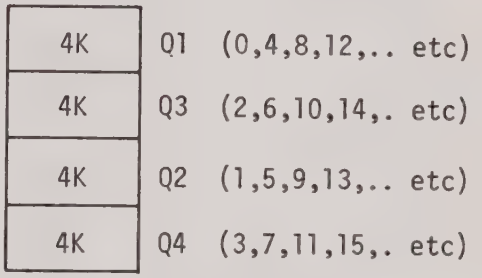



*Figure 7-14*

● Storing Data Groups

The position selected on the MEMORY switch, at the time of acquisition, determines whether the input signal will be recorded by the entire memory or by a subsection of the memory. It also determines where, within the memory, the input signal will be stored.

*EXAMPLE #7-6*

*Figure 7-15: Illustrates that all (16K) words of memory will record the input signal when the MEMORY switch is in the "ALL" position.*

*Figure 7-16: The input signal will be recorded with (8K) words of memory and be stored in subsection H1 or H2, determined by the position of the MEMORY switch.*

*Figure 7-17: The input signal will be recorded with (4K) words of memory and be stored in subsection Q1, Q3, Q2, or Q4, determined by the position of the MEMORY switch.*

*Figure 7-15*

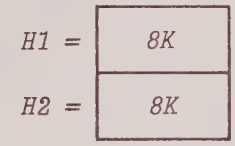



*Figure 7-16*

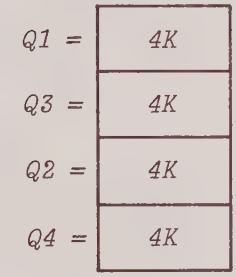



*Figure 7-17*

● Viewing Stored Data Groups

The number of data groups recorded in the display memory and the position selected on the MEMORY switch determine whether single or multiple data groups will be displayed.

The Plug-in must be in the Hold mode.

*EXAMPLE #7-7*

*Figure 7-18: Either one (16K), two (8K), or four (4K) data groups will be displayed with the "ALL" position selected.*

*Figure 7-19: Either a single (8K) or up to two (4K) data groups will be displayed with either the "H1" or "H2" position selected.*

*Figure 7-20: A single (4K) data group will be displayed when the MEMORY switch is placed to either the "Q1, Q3, Q2, or Q4" position.*

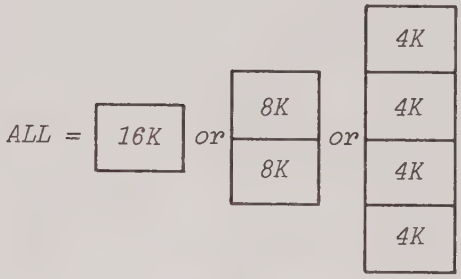



*Figure 7-18*

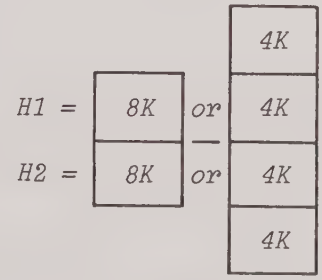



*Figure 7-19*

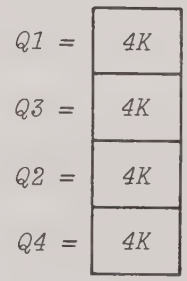



*Figure 7-20*

## FUNCTION & EXECUTE CONTROLS

The FUNCTION switch and EXECUTE button are interactive. The selected function (except for "GRID") will not be performed unless the EXECUTE button is pressed.

NOTE: The Plug-in should be in the Hold mode before executing a function. Otherwise, a trigger will replace the data being manipulated with the data collected during the next sweep.

- PRGM

The PRGM position activates the one-button functions, as selected through recall, from the Program Diskettes when executed. Refer to the *Disk Programs* tab for additional information.

● INVERT

Multiplies the voltage coordinates by (-1) in the YT mode only.

►IMPORTANT: The displayed data group is Inverted around *digital zero* (screen vertical center) and not *analog zero* (Plug-in's Trigger cursor). In order to obtain optimum "mirror-measurements," position the *analog zero* reference as close as possible to *digital zero* (using the POSITION control) when acquiring the signal.

To invert a data group display -

#1. Store the data group.
#2. Place Plug-in into Hold mode.
#3. XY/YT switch: YT
#4. HORIZONTAL EXPANSION: Off
#5. MEMORY switch: Display the data group to be inverted.
#6. FUNCTION switch: Invert
#7. EXECUTE button: Press.

*EXAMPLE #7-8*

*Figure 7-21: MEMORY switch: ALL. Data Group A (analog and digital zeros NOT superimposed) was stored in H1. Data Group B (analog and digital zeros superimposed) was stored in H2.*

*Figure 7-22: MEMORY switch: H1. Data Group A after being inverted.*

*Figure 7-23: MEMORY switch: H2. Data Group B after being inverted.*

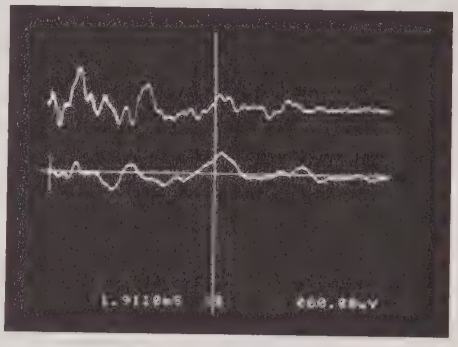


*Figure 7-21*

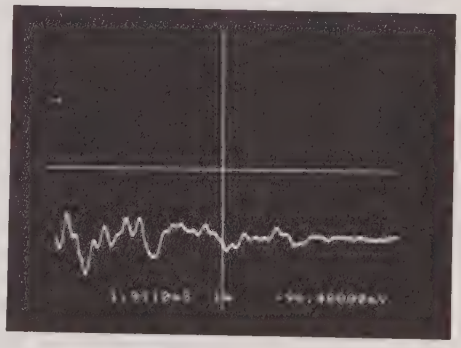


*Figure 7-22*

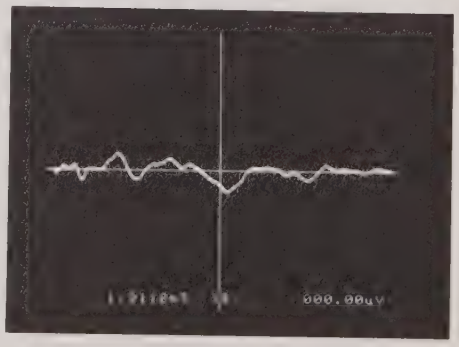


*Figure 7-23*

● SUB

Subtracts one data group from another. Data groups can also be added if the Subtrahend is inverted before executing the SUB function. The SUB function can only be used in the YT mode.

Subtracting data groups from each other is basically the process of storing two data groups in associated memory subsections, selecting which data group will be the subtrahend, and then executing the SUB function.

► IMPORTANT: For optimum results when executing a SUB function, position the channels' *analog zeros* (Plug-in's Trigger cursors) as close to each other as possible when acquiring the signals.

In addition, when subtracting two data groups of opposite polarities (i.e., two out-of-phase sine waves), the two data groups will, in effect, be added. This may cause the resulting display to "roll-over," displaying the top of the data group at screen bottom, or vice-versa. If a "roll-over" occurs after executing a SUB function, execute a second SUB function (returning the display to its original status) and then execute a DATA MOVE function. This may help to eliminate or minimize the "roll-over" effect. If, however, the resulting "subtracted" data group is too large to be fully displayed on the screen, the signals will have to be acquired a second time using a larger ± VOLTS FULL SCALE setting, or the SUBTRACTION Program available on the Program Diskettes must be used.

Table 7-6 tabulates the MEMORY switch positions and corresponding subtraction/addition equations. The resulting data group is stored in the subtrahend's subsection selected on the MEMORY switch.

| MEMORY SWITCH POSITION | EQUATIONS | |
|---|---|---|
| | SUBTRACTION | ADDITION |
| Q1 | Q3 - Q1 | Q3 - (-Q1) |
| Q3 | Q1 - Q3 | Q1 - (-Q3) |
| H1 | H2 - H1 | H2 - (-H1) |
| H2 | H1 - H2 | H1 - (-H2) |
| Q2 | Q4 - Q2 | Q4 - (-Q2) |
| Q4 | Q2 - Q4 | Q2 - (-Q4) |

*Table 7-6*

NOTE: The "ALL" position is not a valid selection when executing a SUB function.

••Subtracting Data Groups

To subtract a data group from another:

#1. Store the data groups to be subtracted in associated sub-sections. (i.e, Q1 & Q3, Q2 & Q4, or H1 & H2.)

#2. Place the Plug-in into the Hold mode.

#3. XY/YT switch: YT

#4. HORIZONTAL EXPANSION: Off

#5. FUNCTION switch: Sub

#6. MEMORY switch: Place switch to subtrahend subsection position.

#7. EXECUTE button: Press.

Pressing the EXECUTE button again will return the data groups to their original values.

*EXAMPLE #7-9*

*Figure 7-25 illustrates the effect of subtracting one of the data groups in Figure 7-24 from the other.*

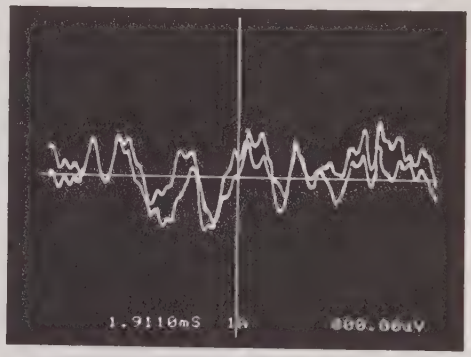


*Figure 7-24*

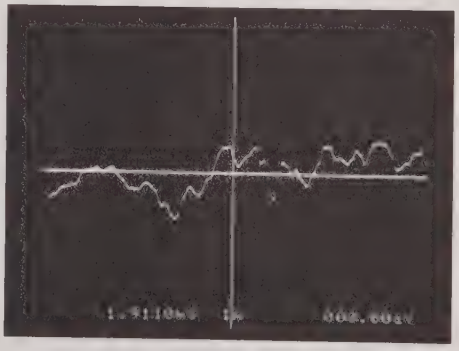


*Figure 7-25*

••Adding Data Groups

To add two data groups:

#1. Store the data groups to be added in associated subsections, (i.e., Q1 & Q3, Q2 & Q4, or H1 & H2.)

#2. Place the Plug-in into the Hold mode.

#3. XY/YT switch: YT

#4. HORIZONTAL EXPANSION: Off

#5. MEMORY switch: Place switch to subtrahend subsection position.

#6. FUNCTION switch: Invert

#7. EXECUTE button: Press.

#8. FUNCTION switch: Sub

#9. EXECUTE button: Press.

Executing a second SUB function and then an INVERT function restores the data groups to their original values.

*EXAMPLE #7-10*

*Figure 7-27 illustrates the effect of adding the two data groups shown in Figure 7-26.*

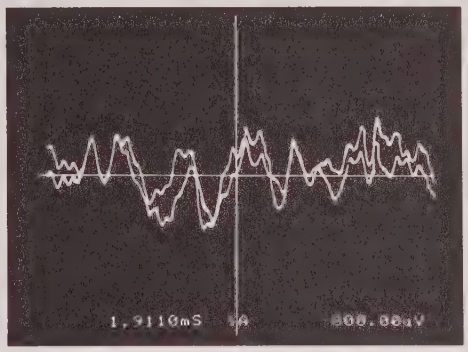



*Figure 7-26*

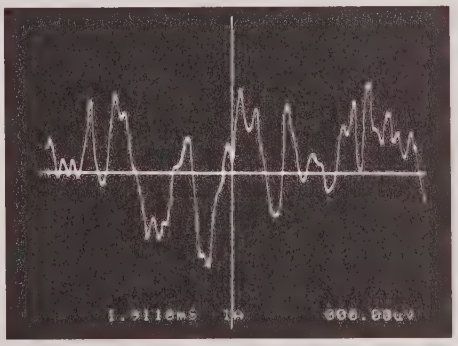


*Figure 7-27*

● DATA MOVE

Typically used to superimpose a stored data group over another for comparison. The data point intersected by the Mainframe's vertical cursor repositions to the level of the horizontal cursor. All other data points shift by the same amount. The DATA MOVE function can only be used in the YT mode.

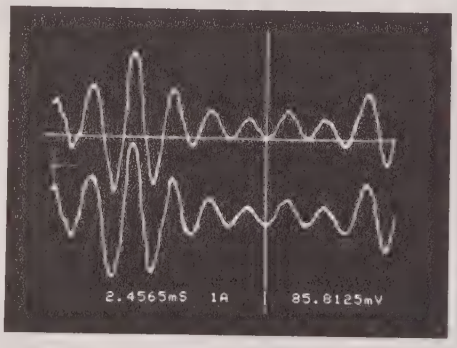



*Figure 7-28*

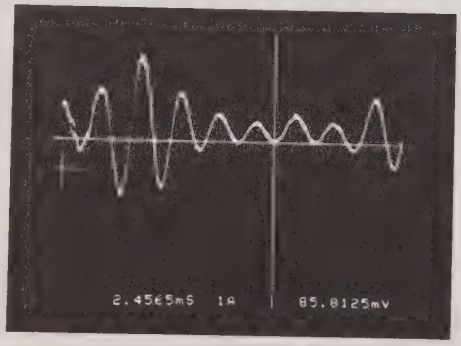



*Figure 7-29*

●●Data Moving One Data Group For Visual Comparison With Another

To data move a data group:

#1. Store the data groups in associated subsections, (i.e., Q1 & Q3, Q2 & Q4, or H1 & H2.)

#2. Place the Plug-in into the Hold mode.

#3. MEMORY switch: Display both data groups.

#4. Position the horizontal cursor at the level to which the data group is to be moved.

#5. MEMORY switch: Display the data group to be moved.

#6. Position the vertical cursor over the data point that is to be vertically repositioned.

#7. FUNCTION switch: Data Move

#8. EXECUTE button: Press.

#9. MEMORY switch: Display both data groups.

*EXAMPLE #7-11*

*Figure 7-29 illustrates the effect of data moving one of the data groups in Figure 7-28.*

● RESET NUMERICS

The letters "RN" appear below the status line on the display screen when the RESET NUMERICS function is selected. They disappear from the screen when the FUNCTION switch is placed to a different position.

••With AUTOCENTER and YT Modes On

Provides a simple means by which measurements can be made relative to a new time and voltage origin, (0,0).

The new (0,0) origin can be at any point on the screen and is determined by the position of the Mainframe's crosshair when the RESET NUMERICS function is executed. This permits easy measurements of peak-to-peak voltages, time relationships between any two points, and any other inspections that require selectable (0,0) origins.

The vertical position of the crosshair determines the zero voltage level (V=0). The horizontal position of the crosshair determines the zero time origin (T=0). Therefore, if the crosshair is superimposed over a data point, as it will be in the AUTOCENTER mode, that data point will become the new (0,0) origin when the RESET NUMERICS function is executed.

The Plug-in's Trigger cursor will immediately "jump" to the position of the Mainframe's crosshair as soon as the EXECUTE button is pressed. This allows the operator to inspect other points of interest on the displayed data group without losing track of the new (0,0) origin.

The time and voltage numerics will return to the absolute values relative to the original (0,0) origin when the FUNCTION switch is placed to a different position.

••With AUTOCENTER and XY Modes On

The left numerics (X-axis' voltage) and right numerics (Y-axis' voltage) reset to (0,0), corresponding to the data point coordinate intersected by the Mainframe's crosshair, when the RESET NUMERICS function is executed and the AUTOCENTER switch is on.

Refer to Page 7-16, XY-YT Switch, for additional information on the XY mode of operation.

*EXAMPLE #7-12*

*Figure 7-30: Typical display with AUTOCENTER selected.*

*Figure 7-31: The same display after executing the RESET NUMERICS function. The Plug-in's trigger crosshair has repositioned to the Mainframe's crosshair and both numerics have reset to zero.*

*Figure 7-32: The crosshair has been repositioned and the numerics reflect the selected data point's values relative to the new origin.*

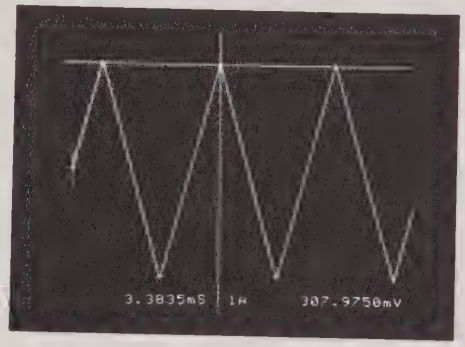



*Figure 7-30*

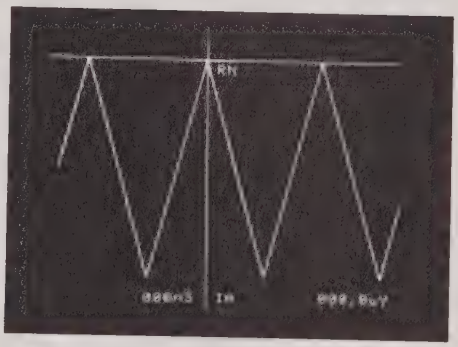


*Figure 7-31*

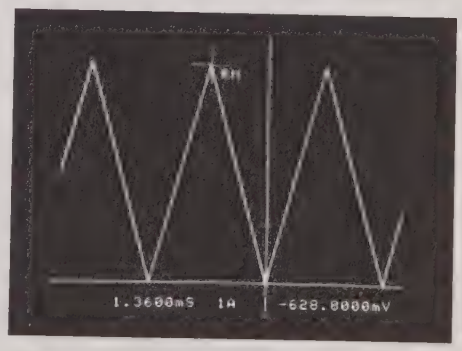



*Figure 7-32*

••With Autocenter Off

The left and right numerics will always reset to zero when the RESET NUMERICS function is executed.

However, when in the YT mode and with AUTOCENTER off, only the time numerics will be affected when the vertical cursor is moved to a new point of interest. The voltage numerics will remain at zero (the new position of the horizontal cursor) unless the horizontal cursor is moved.

NOTE: The AUTOCENTER switch must be on when operating in the XY mode.

*EXAMPLE #7-13*

*Figure 7-33: Typical display with AUTOCENTER turned off.*

*Figure 7-34: The same display after executing the RESET NUMERICS function. The Plug-in's Trigger cursor has repositioned to the Mainframe's crosshair and both numerics have reset to zero.*

*Figure 7-35: The vertical cursor has been repositioned and the time numerics reflect the selected data point's time coordinate with respect to the new time zero origin. The voltage numerics will remain at zero unless the horizontal cursor is moved.*

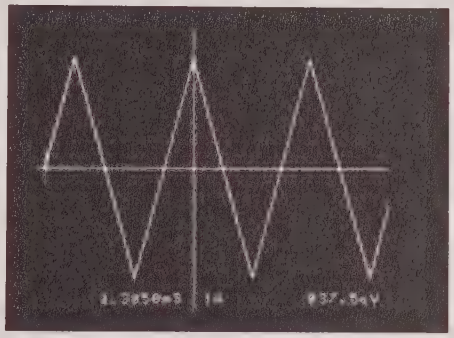


*Figure 7-33*

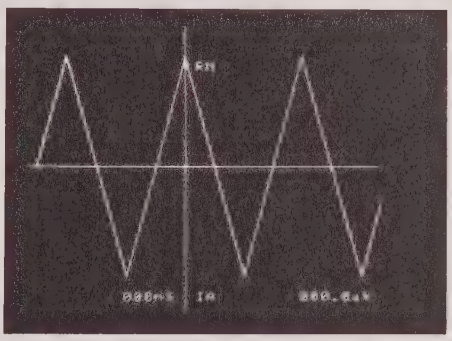


*Figure 7-34*

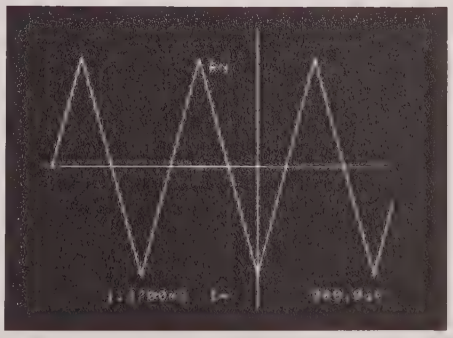


*Figure 7-35*

- GRID

An electronic graticule appears on the screen when the GRID position is selected on the FUNCTION switch. The Plug-in's Trigger cursor remains displayed. However, the Mainframe's vertical and horizontal cursors disappear.

The time numerics reflects the time per vertical line and the voltage numerics reflects the volts per horizontal line.

NOTE: The grid expands to the horizontal limits of the display screen when the HORIZONTAL EXPANSION switch is turned on. This occurs because all (16K) words of memory are used during expansion only. Regardless of whether or not expansion is in use, the time numerics automatically compensate for the difference in distances between the vertical lines.

This function is very useful when photographs are being used to permanently record the displays.

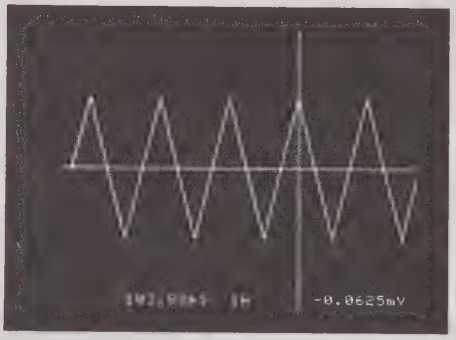



*Figure 7-36*

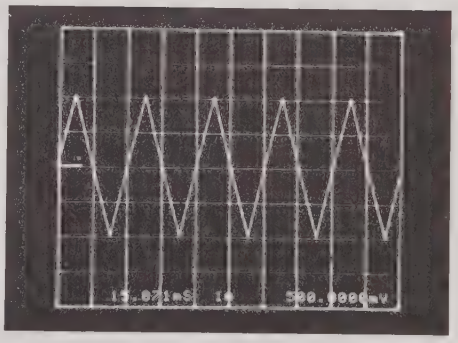


*Figure 7-37*

*EXAMPLE #7-14*

*Figure 7-35: Typical display of an input signal. The Time Per Point was 10 uSec's and the Volts Full Scale was ±2 volts.*

*Figure 7-36: The same display after selecting the GRID position.*

●PEN

NOTE: The following descriptions apply only to the XY and Strip Chart (YT) recorders. Refer to the tab labeled *Digital Plotter* for information on the digital plotter.

The PEN controls, Figure 7-38, are mounted on the rear panel of the Mainframe. These permit the recording of displayed data groups on either an XY or Strip Chart (YT) pen recorder.

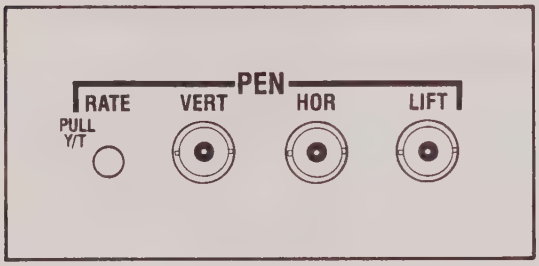



*Figure 7-38*

●●Rate Control

The RATE control is a dual function device. It is used to select whether the outputs of the PEN BNCs will drive either an XY or strip chart (YT) recorder. To select an XY recording, press the RATE control in. For a strip chart (YT) recording, pull the control out.

In the XY mode, the readout rate is automatically varied to read data out at a higher rate in featureless regions and as slow as one point in two seconds whenever substantial pen excursions are involved. The RATE control allows the operator to adjust this speed range to adapt to very slow or faster pen recorders.

In the YT mode, the RATE control adjusts the readout rate to suit the particular strip chart (YT) recorder in use.

••Vertical & Horizontal BNCs

The VERT and HOR output BNCs are at approximately zero volts before the pen readout is executed.

On an XY recorder, this corresponds to a vertical, negative full scale position on the paper and the left-most part of the waveform.

The VERT and HOR output BNCs will return to approximately zero volts when the pen recording is completed.

••Lift BNC

The LIFT BNC's output voltage, before the pen readout is executed, depends upon which version of Mainframe is present:

a. VERSION 1.0 thru 1.9 - The output is approximately 5 volts.

b. VERSION 2.0 and above - The output is rated up a a maximum of 30 volts at 200 milliamps.

To determine which version of Mainframe is present:

#1. Place the FUNCTION switch to any position other than PEN or PGRM.

#2. Simultaneously press and hold the left and right CURSOR buttons and then -

#3. Press and hold the EXECUTE button.
   a. The Mainframe's version number will be displayed on the screen.

The LIFT BNC's output will drop to approximately zero volts when the pen readout is executed, lowering the pen nib onto the paper. Upon completion of the pen recording, the output voltage will once again rise and the pen nib will rise off of the paper.

The LIFT BNC output is used for connection to the EXTERNAL or REMOTE PEN LIFT input on recorders with this option.

••Border Confirmation

The full display border limits within which the displayed waveform will be duplicated on the paper can be confirmed by:

#1. FUNCTION switch: Pen

#2. AUTOCENTER switch: Place to the "ZERO" position and hold.

#3. EXECUTE button: Press.

#4. AUTOCENTER switch: Release.

The pen will move from the lower left border limit to the upper right border limit and then back again. The pen will remain in the "up" position during this border limit confirmation.

NOTE: The vertical full scale limit will be equal to the ±VOLTS FULL SCALE switch setting. The horizontal full scale limit will be equal to the horizontal full scale of the display screen.

If the border limits must be corrected, the above procedure must be repeated for each confirmation.

NOTE: A border will not be drawn on the paper.

••Reproduction of Waveforms

After confirming the border limits, the displayed waveform can be reproduced by pressing the EXECUTE button. The AUTOCENTER switch must be in the "OFF" position and the FUNCTION switch in the "PEN" position.

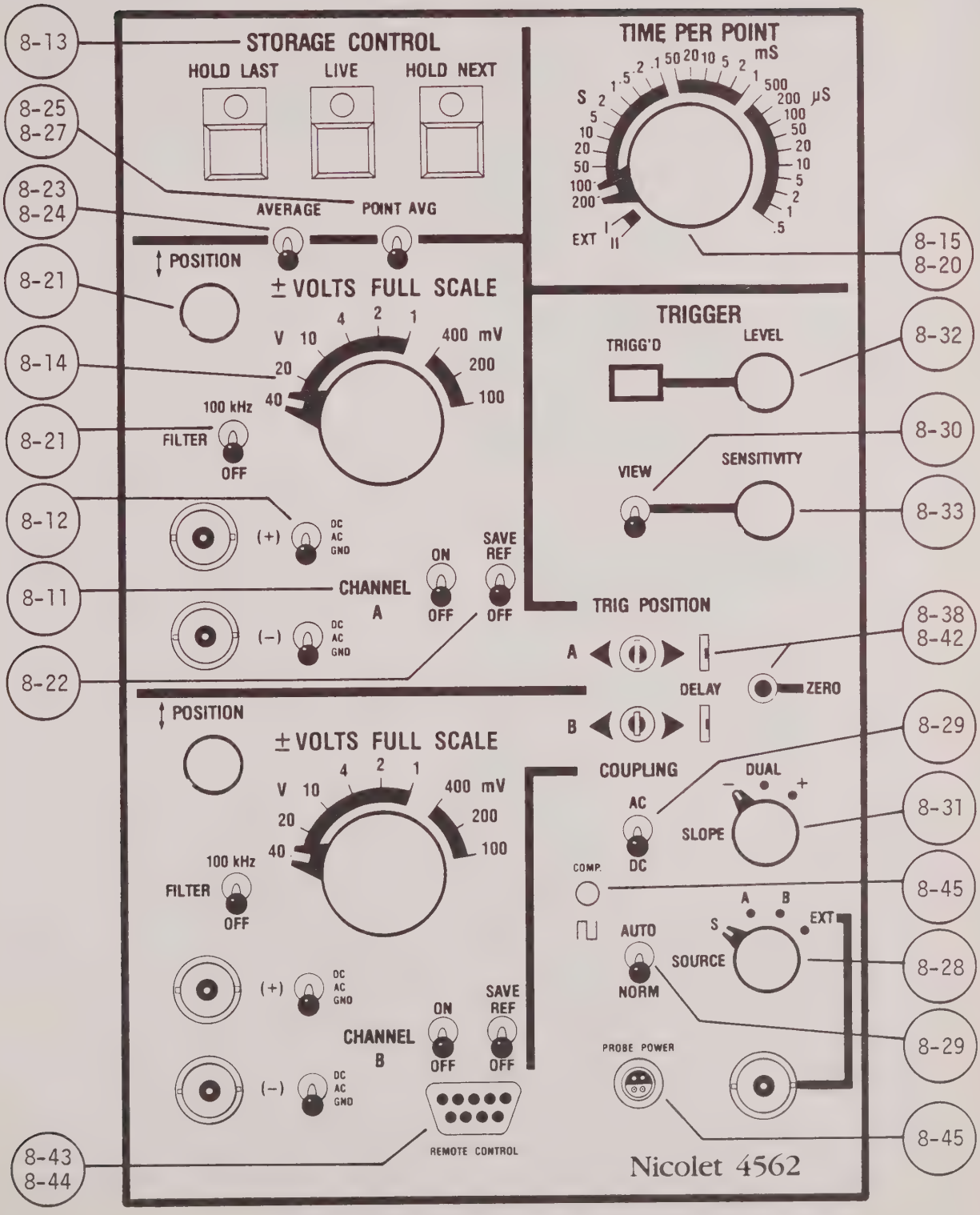
If display expansion is in use, only that portion of the displayed waveform will be reproduced by the pen recorder.

The pen recording will not include the horizontal or vertical cursors, trigger cursor, or numerics.

If a pen recording of two superimposed waveforms is required, first record one, then the other. Otherwise the pen will alternate vertically between the data points of each waveform.

Moving the FUNCTION switch to a different position will abort the pen recording.

# Model 4562 Plug-in



## INTRODUCTION

The Model 4562, two channel Plug-in includes two high impedance, differential amplifiers; two 12-bit, 500 nanosecond digitizers; and a single 16K word memory.

Other features include -

- Single-ended or differential amplifiers.
- Positive, negative, or dual slope triggering.
- Normal, Pre- and Post-trigger, and Delayed trigger displays.
- A Trigger View mode to assist in the selection of the trigger's qualifying characteristics.
- Sweep Averaging, Point Averaging, and 100 kHz Filter to reduce the effects of "noise" on the signals.
- A Save Reference mode to compare "live" and saved signals.
- Remote control abilities.
- Test point compensation.
- A ±12 VDC probe power output.

►IMPORTANT: The term "Hold mode," in the following discussions, signifies that the Plug-in's HOLD LAST LED is illuminated only. The Live and Hold Next LEDs are turned off.

The Plug-in should be in the Hold mode whenever a Plug-in parameter is changed. Otherwise, the operator must either press the LIVE button to reset the Plug-in, or wait until after the next sweep is completed before the 4094 will acknowledge the parameter change(s).

The Plug-in is in the Hold mode when only the Hold Last LED is illuminated. If a sweep is not in progress, the Hold mode can be selected by pressing the HOLD LAST button. If, however, a sweep is currently in progress, the Hold mode can be selected by:

#1. HOLD LAST button: Press and hold.
#2. LIVE button: Press momentarily.
#3. HOLD LAST button: Release.

NOTE: The following descriptions are for single Plug-in operation only. Refer to the *Multiple Plug-ins* tab, after reading this section of the manual, for additional information.

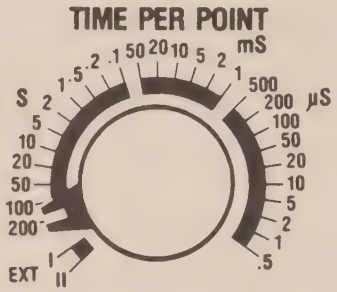
## STORAGE CONTROL BUTTONS

The Storage Control buttons determine whether the displayed data groups will remain "live" or be stored in the display memory.

- LIVE - New signals are acquired and displayed on the screen each time a valid trigger is received.
- HOLD NEXT - The signal following the next valid trigger is stored in the display memory and displayed on the screen.
- HOLD LAST - The signal that followed the last valid trigger is stored in the display memory and displayed on the screen; including a signal already in progress at the moment the button is pressed.

## CHANNEL SWITCH

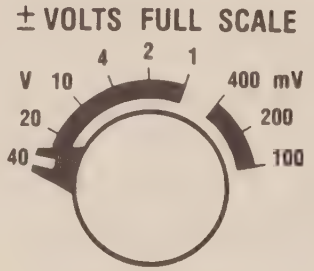
The "ON" position allows the display memory to record data acquired by the associated channel and display it on the screen.




## TIME PER POINT

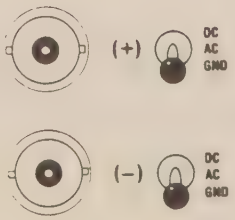
Selects the time resolution of the signal to be acquired.

Sweep speeds are expressed as time-per-point rather than time-per-centimeter.



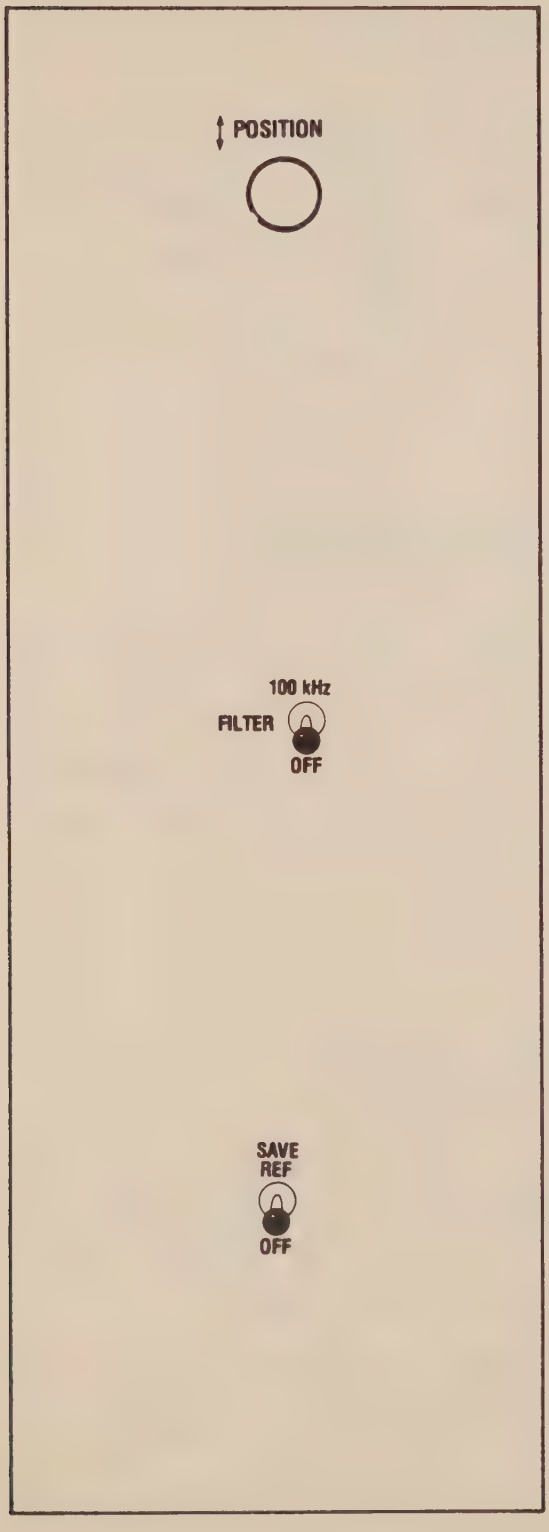

## ± VOLTS FULL SCALE SWITCH

Allows the oscilloscope to accept input signals ranging from ±100 millivolts to ±40 volts full scale.




## DC/AC/GND SWITCH

- GND - Grounds the amplifier's input.
- DC - Allows both ac and dc signal components to enter the amplifier.
- AC - Blocks the dc component. Allows only the ac component to enter the amplifier.




## POSITION CONTROL

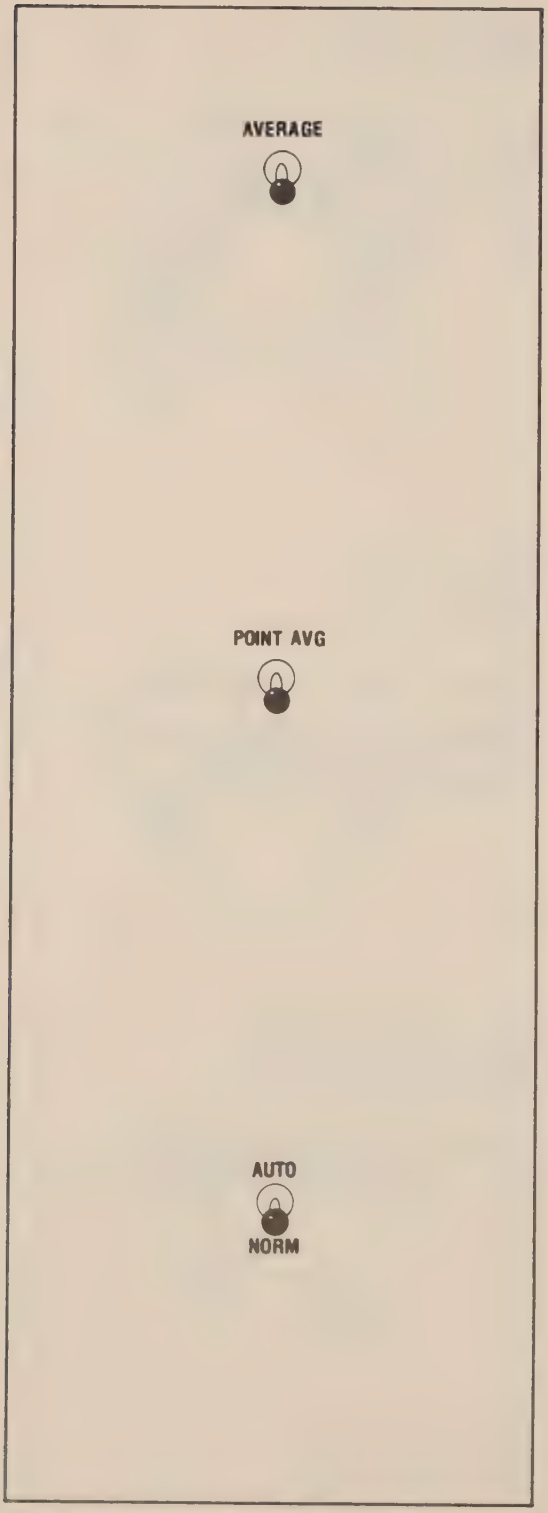
Vertically positions the displayed signal on the screen.

## FILTER SWITCH

Filters high frequency "noise" components to ground. Used with low frequency input signals.

## SAVE REFERENCE SWITCH

Allows the operator to compare "live" and saved signals in the Live mode.




## AVERAGE SWITCH

Reduces "noise" on recurrent signals by averaging (from sweep to sweep) sampled voltages acquired equidistant with respect to each trigger, (T=0).

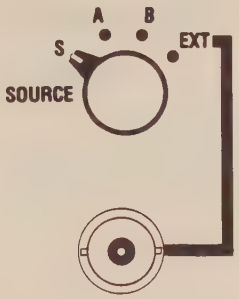
## POINT AVERAGE SWITCH

Reduces "noise" on single sweep input signals when the time-per-point is greater than 500 µS by averaging the input signal at a constant sampling rate of 250 µS/point between each displayed data point.

## AUTO/NORM SWITCH

Determines whether the trigger will be generated internally in the absence of a valid trigger signal or by an external input signal.

- AUTO - Internally triggered.
- NORM - Externally triggered.




## TRIGGER SOURCE SWITCH

Selects the source of the input trigger signal.

- (S) - "Slave," trigger comes from the "master" Plug-in when multiple Plug-ins are being triggered from a common source. The "master" Plug-in's switch must be in the (A), (B), or (EXT) positions. The "slave" Plug-in(s) must be in the (S) position.
- (A) - Trigger signal is derived from channel A.
- (B) - Trigger signal is derived from channel B.
- EXT - Trigger signal is derived from the EXT input BNC.

## TRIGGER SLOPE SWITCH

Selects the signal's voltage transitions that will qualify it as a valid trigger.

- (+) - Positive-going only.
- (-) - Negative-going only.
- DUAL - Either positive- or negative-going voltage transitions.

## TRIGGER COUPLING SWITCH

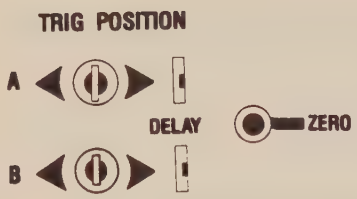
Determines whether or not the dc component of the input signal will be blocked.

- AC - Only the ac component of the signal is applied to the trigger circuit. The dc component is blocked.
- DC - All frequency components of the input signal are applied to the trigger circuit. Used when low frequency input signals are to be inspected or the dc component is of importance.

## TRIGGER LEVEL CONTROL & TRIGG'D LED

Adjusts the voltage level that must be crossed by the triggering signal to qualify as a valid trigger.

The green LED indicator illuminates each time a valid trigger initiates a sweep.




## TRIGGER POSITION CONTROLS

Selects whether the screen will display post-trigger events (Normal Trigger), both pre- and post-trigger events (Cursor Trigger), or events that occurred following a specific time delay (Delayed Trigger).

- Normal Trigger - Press the Zero button.
- Cursor Trigger - Press the paddle switch to the right.
- Delayed Trigger - Press the paddle switch to the left.

The adjacent LED indicator(s) illuminate when either Cursor or Delayed Trigger modes are selected.

## TRIGGER SENSITIVITY & VIEW CONTROLS

The Trigger SENSITIVITY control adjusts the "window" (voltage span) that the signal must pass through before it will qualify as a valid trigger.

The VIEW switch, when turned on, introduces a "trigger adjust" display. This display assists the operator in the selection of specific characteristics that will qualify the signal as a valid trigger.

## COMPENSATION POINT

Placing the test probe against the compensation point produces a square-wave display. This display assists the operator in the compensation of the test probe for the best response times.

## PROBE POWER CONNECTOR

Provides a +12 and/or -12 VDC output.

## REMOTE CONTROL CONNECTOR

Permits remote control of the Plug-in.

## CHANNEL SWITCHES

The display memory will not store data unless the ON/OFF switch associated with the channel acquiring data is placed to the "ON" position.

For example, the CHANNEL A switch must be in the "ON" position if channel A is acquiring input signals.

If only one channel (typically channel A) is being used to acquire input signals, turn the unused channel off. This allows the entire display memory of 15,872 addresses to record data if the Mainframe's MEMORY switch is in the "ALL" position.

The number of addresses that will record each input signal depends upon the positions of the CHANNEL and MEMORY switches. Table 8-1 tabulates the number of addresses that will record each input signal.

NOTE: Table 8-1 is for single Plug-in operation only.

| CHANNEL SWITCH | | MEMORY SWITCH POSITION | | |
|---|---|---|---|---|
| A | B | ALL | HALVES | QUARTERS |
| ON | OFF | *15,872* | *7,936* | *3,968* |
| OFF | ON | *15,872* | *7,936* | *3,968* |
| ON | ON | *7,936* | *3,968* | *1,984* |

*Table 8-1*

## DC/AC/GND SWITCHES

This instrument uses high impedance, differential amplifiers. The high impedances ($10^6$ ohms) and low bias currents ($10^{-10}$ amps) allow high impedance signal sources to be measured because of the light loading effect of the amplifiers.

The DC/AC/GND switches control the operation of the associated amplifiers' inputs.

> CAUTION - Always ensure that the input signals never exceed the maximum, allowable input voltage, with respect to ground, listed under tab *Specifications*.

- DC
  Allows both ac and dc components of the input signal to enter the amplifier.
- AC
  Blocks the dc component. Only the ac component of the signal enters the amplifier.
- GND
  Grounds the amplifier's input. Neither ac nor dc components will enter the amplifier.

NOTE: Always ground an unused amplifier input by placing the associated DC/AC/GND switch to the "GND" position. An ungrounded, unused input will introduce "noise."

Each of the amplifiers can be used as either Differential or Single-ended amplifiers.

- DIFFERENTIAL AMPLIFIERS

Placing the channel's DC/AC/GND switches to either the "DC" or "AC" position allows the amplifier to measure the difference between the voltages applied to the (+) and (-) input BNCs.

- SINGLE-END AMPLIFIERS

Placing one of the channel's DC/AC/GND switches to "GND" and the remaining switch to either "DC" or "AC" allows the oscilloscope to display the voltages applied to the active input.

## STORAGE CONTROL BUTTONS

The Storage Control consists of three buttons: LIVE, HOLD NEXT and HOLD LAST.

These buttons determine whether or not data stored in the display memory will be replaced when a valid trigger is received.

● LIVE

Pressing the LIVE button erases the displayed data from the screen, readying it for the next display.

It also serves as a "master reset," enabling the Plug-in to determine whether or not any of the controls have been altered since the last signal acquisition.

➤IMPORTANT: Changes made to the Plug-in's controls, while the LIVE LED is illuminated, will NOT be acknowledged until either the operator presses the LIVE button or the next sweep is completed.

● HOLD NEXT

The Live mode must be activated before the HOLD NEXT button is pressed.

The stored data is replaced when the next valid trigger is received. The Plug-in enters the Hold mode as soon as the sweep is completed.

● HOLD LAST

Pressing the HOLD LAST button allows a sweep currently in progress to be completed and then inhibits any further sweeps.

Data stored in the display memory is protected when only the Hold Last LED is illuminated, (Hold mode).

NOTE: If data stored in portions of the memory is to be saved, ensure that the Live LED is off before repositioning the Mainframe's MEMORY switch. Otherwise, data will be replaced if a valid trigger is received.

••Hold Mode

The Plug-in should be in the Hold mode (only the Hold Last LED is illuminated) whenever a Plug-in parameter is changed. See IMPORTANT note on Page 8-1.

● REMOTE CONTROL

Refer to Page 8-43, *Remote Control Connector* descriptions.

## ±VOLTS FULL SCALE SWITCH

Allows signals ranging from ±100 millivolts to ±40 volts full scale to be measured when the X1 probe is used.

A maximum of ±400 volts full scale can be measured when the optional X10 probe is used.

The voltage numerics are directly related to the measured voltages when either the X1 or special X10 probe is used. Refer to tab *Accessories* for information on the special X10 probe.

The screen can display up to 4096 voltage levels when the VERTICAL EXPANSION switch is turned off.

If the zero volts reference is vertically centered on the screen, the positive voltages will be displayed above the zero volts level by up to 2047 levels. Negative voltages will be displayed below the zero volts level by up to 2048 levels. Refer to Figure 8-1.

Table 8-2 tabulates the voltage increment of each level (volts per level) according to the position selected on the ±VOLTS FULL SCALE switch.

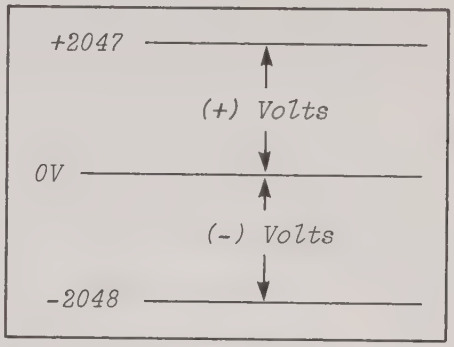



*Figure 8-1*

| ± V.F.S. | VOLTS PER LEVEL |
|---|---|
| 100 mV | *50 µV* |
| 200 mV | *100 µV* |
| 400 mV | *200 µV* |
| 1 V | *500 µV* |
| 2 V | *1 mV* |
| 4 V | *2 mV* |
| 10 V | *5 mV* |
| 20 V | *10 mV* |
| 40 V | *20 mV* |

*Table 8-2*

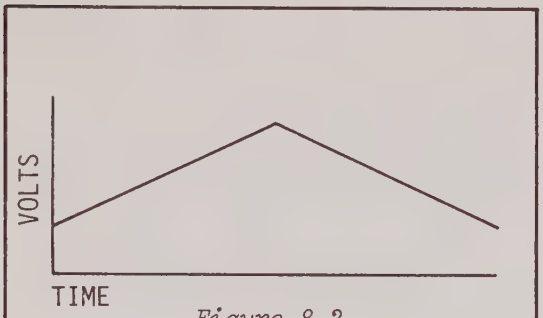



*Figure 8-2*

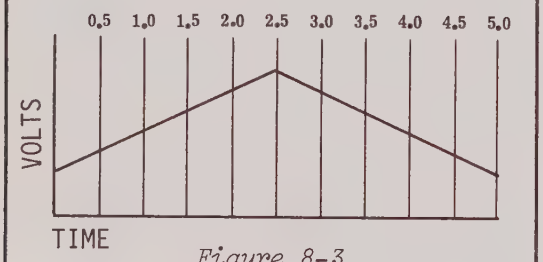



*Figure 8-3*

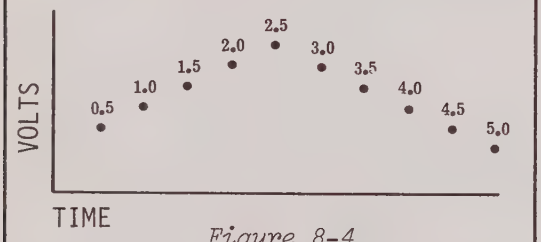



*Figure 8-4*

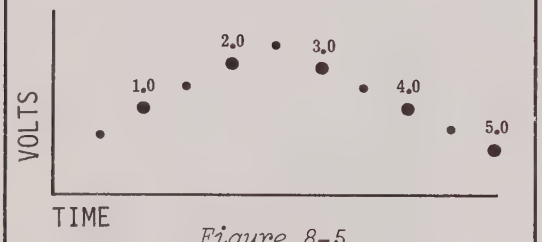



*Figure 8-5*

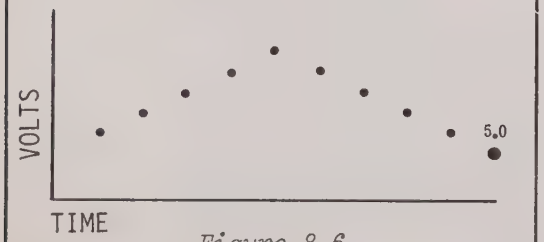



*Figure 8-6*

## TIME PER POINT SWITCH

Determines the time resolution of the displayed signal. The faster the time-per-point when the signal is acquired, the higher the time resolution.

The Plug-in samples and digitizes the input signal's voltages once every 500 nanoseconds. This sampling rate is preset within the oscilloscope's circuitry. However, which of the sampled voltages will be selected for display is determined by the TIME PER POINT switch.

*EXAMPLE #8-1*

*Figure 8-2: A typical input signal.*

*Figure 8-3: The 0.5 microsecond sampling rate superimposed over the signal.*

*Figure 8-4: The resulting digitized samples represented by dots.*

*Figure 8-5: Assume a time-per-point of 1 uSec. Every other digitized sample (larger dots) are selected for display.*

*Figure 8-6: Assume a time-per-point of 5 uSec's. Every tenth digitized sample (large dot) is selected for display.*

The number of allotted addresses (words) with which the display memory will record each input signal depends upon -

#1. The positions of the CHANNEL A and B "ON/OFF" switches; and

#2. The position selected on the Mainframe's MEMORY switch

Table 8-3 tabulates the approximate number of memory addresses that will record each input signal.

| CHANNEL SWITCH | | MEMORY SWITCH POSITION | | |
|---|---|---|---|---|
| A | B | ALL | HALVES | QUARTERS |
| ON | OFF | *16K* | *8K* | *4K* |
| OFF | ON | *16K* | *8K* | *4K* |
| ON | ON | *8K* | *4K* | *2K* |

*Table 8-3*

NOTE: Table 8-3 is for single Plug-in operation only.

## SWEEP TIMES

Table 8-4 tabulates the approximate sweep times for single-channel measurements. For multiple channels, divide the listed times accordingly:

Two channels ---------- (2)
Three or four channels --------- (4)

| TIME PER POINT SWITCH | MEMORY SWITCH POSITIONS (Data Points Per Sweep) | | |
|---|---|---|---|
| | ALL (15,872) | H1/H2 (7,936) | Q1/Q2/Q3/Q4 (3,968) |
| | *Milliseconds Per Sweep* | | |
| 0.5 µS | 7.940 | 3.970 | 1.985 |
| 1.0 | 15.880 | 7.940 | 3.970 |
| 2.0 | 31.760 | 15.880 | 7.940 |
| 5.0 | 79.400 | 39.700 | 19.850 |
| 10.0 | 158.800 | 79.400 | 39.700 |
| 20.0 | 317.600 | 158.800 | 79.400 |
| 50.0 | 794.000 | 397.000 | 198.500 |
| 100.0 | 1588.000 | 794.000 | 397.000 |
| 200.0 | 3176.000 | 1588.000 | 794.000 |
| 500.0 | 7940.000 | 3970.000 | 1985.000 |
| | *Minutes Per Sweep* | | |
| 1 mS | 0.264 | 0.132 | 0.066 |
| 2 | 0.528 | 0.264 | 0.132 |
| 5 | 1.320 | 0.660 | 0.330 |
| 10 | 2.640 | 1.320 | 0.660 |
| 20 | 5.280 | 2.640 | 1.320 |
| 50 | 13.200 | 6.600 | 3.300 |
| | *Hours Per Sweep* | | |
| 0.1 S | 0.440 | 0.220 | 0.110 |
| 0.2 | 0.880 | 0.440 | 0.220 |
| 0.5 | 2.200 | 1.100 | 0.550 |
| 1 | 4.400 | 2.200 | 1.100 |
| 2 | 8.800 | 4.400 | 2.200 |
| 5 | 22.000 | 11.000 | 5.500 |
| 10 | 44.000 | 22.000 | 11.000 |
| 20 | 88.000 | 44.000 | 22.000 |
| 50 | 220.000 | 110.000 | 55.000 |
| 100 | 440.000 | 220.000 | 110.000 |
| 200 | 880.000 | 440.000 | 220.000 |

*Table 8-4*

● EXT I & II POSITIONS

The EXT I (fast) and EXT II (slow) time-per-point positions are used when -

#1. The desired time-per-point is not available on the TIME PER POINT switch; or

#2. The sampling rate is generated from a nonlinear time base.

The number of allotted addresses (words) that will record each input signal depends upon -

#1. The positions selected on the CHANNEL A and B "ON/OFF" switches; and

#2. The position selected on the Mainframe's MEMORY switch.

Table 8-5 tabulates the corresponding number of memory addresses that will record each input signal.

NOTE: Table 8-5 is for single Plug-in operation only.

The sampling of the input signal will begin 200 nS to 220 nS (and end 540 nS to 560 nS) after the "EP" command is applied to the Remote Control Connector.

| CHANNEL SWITCH | | MEMORY SWITCH POSITION | | |
|---|---|---|---|---|
| A | B | ALL | HALVES | QUARTERS |
| ON | OFF | *15,872* | *7,936* | *3,968* |
| OFF | ON | *15,872* | *7,936* | *3,968* |
| ON | ON | *7,936* | *3,968* | *1,984* |

*Table 8-5*

IN EXT I (fast) mode, a delay will occur between the time of the first sample and the time at which a display will appear. This delay occurs because the samples are stored by the Plug-in's buffer memory before being "dumped" into the display memory.

This time delay can be approximated by multiplying the allotted addresses (from Table 8-5) by the average time period between each sample. See Equation 8-1.

Time Delay = (addresses) x (period)

*Equation 8-1*

In EXT II (slow) mode, each sample will be displayed as soon as it is acquired, allowing real-time monitoring of slow signals.

● EXT I Position

The EXT I position is used when the sampling rate is between 3.5 µS and 35 µS (or 3.5 µS and 120 µS if averaging is applied). The EXT I mode requires two external commands to acquire samples:

#1. A valid trigger command; and
#2. A TTL input signal (EP command) applied to the Remote Control Connector.

The trigger command initiates the sampling sequence and first data point acquisition, and the "EP" commands determine the sampling rate. Samples are acquired within 220 nS of the leading, positive edge of the "EP" commands. The buffer memory stores all of the data points before "dumping" them into the display memory.

NOTE: The Point Average mode is not operable in the EXT I mode.

*EXAMPLE #8-2*

*Figure 8-7: Typical input signal.*

*Figure 8-8: "EP" commands superimposed over the input signal.*

*Figure 8-9: A valid trigger occurring at that point in time.*

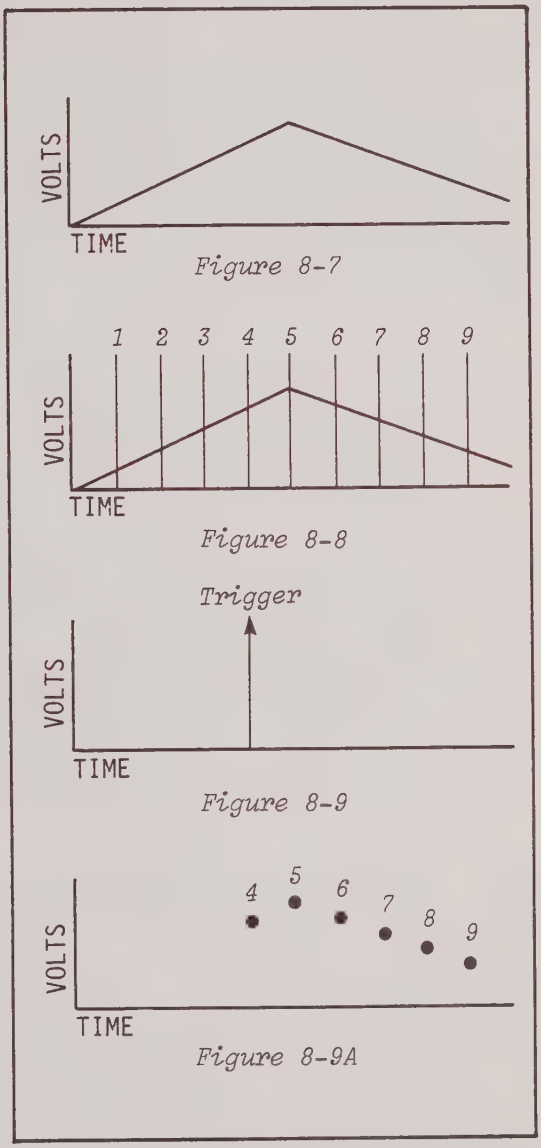



*Figure 8-9A: The corresponding digitized samples, represented by the dots, that will be stored in the display memory.*

● EXT II Position

The EXT II position is used when the sampling rate is equal to, or slower than 35 µS (or 120 µS if averaging is applied). The EXT II mode requires two external commands to acquire samples:

#1. A valid trigger command; and
#2. A TTL input signal (EP command) applied to the Remote Control Connector.

The trigger command initiates the sampling sequence and the first data point acquisition, and the "EP" commands determine the sampling rate. Each data point will immediately appear on the display screen as each one is acquired.

NOTE: The Point Average mode is not operable in the EXT II mode.

*EXAMPLE #8-3*

*Figure 8-10: Typical input signal.*

*Figure 8-11: "EP" commands superimposed over the input signal.*

*Figure 8-12: A valid trigger occurring at that point in time.*

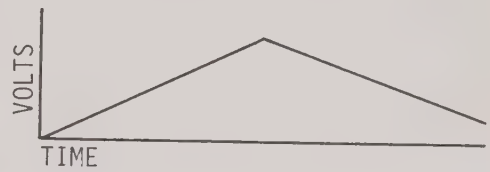



*Figure 8-10*

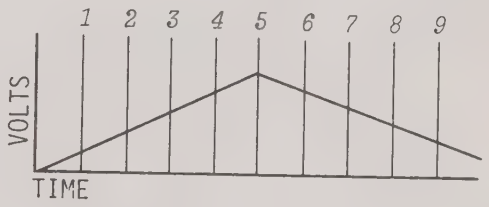



*Figure 8-11*

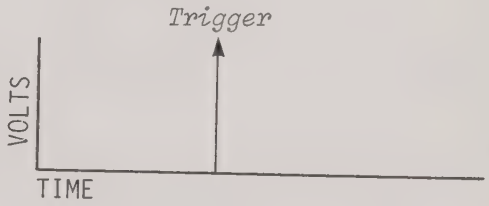



*Figure 8-12*

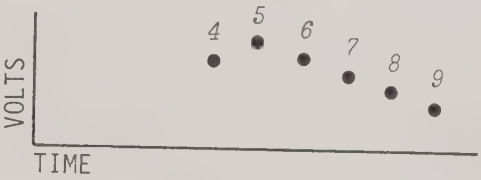



*Figure 8-13*

*Figure 8-13: The corresponding digitized samples, represented by the dots, that will be stored in the display memory.*

## FILTER SWITCH

Rejects high frequency "noise" components on the input signal.

This feature can be used in any acquisition mode, including Average and Point Average.

NOTE: 100 KHz = -3db/point.

## POSITION CONTROL

Vertically repositions a "live" display on the screen.

NOTE: The POSITION control does not introduce a dc offset to the signal. Rather, it varies the location of the zero volts reference on the screen by up to 60% of the selected Volts Full Scale.

For example, if the selected Volts Full Scale equals ±1V, the display can be varied from (+1.6 V to -0.4 V) down to (-1.6 V to +0.4 V) by using the POSITION control.

The voltage numerics will remain unchanged when the POSITION control is used.

## SAVE REFERENCE SWITCH

►IMPORTANT: The Trigger View mode overrides the Save Reference mode. See IMPORTANT note on Page 8-30.

Allows "live" and stored signals to be compared when the Plug-in is operating in the Live mode. This enables the operator to observe the effects of altering the characteristics of the input signal.

Turning the SAVE REFERENCE switch on causes alternate, displayed data point coordinates to become "frozen" in the display memory's addresses. The remaining addresses continue to record changes in the input signal and display these changes superimposed over the "frozen" data points. The reference of the"frozen" display is protected in the Live mode.

In addition, the Plug-in/Channel numerics will also display a letter "R" suffix indicating which data points have been saved ("frozen").

The display returns to normal operation when the switch is turned off.

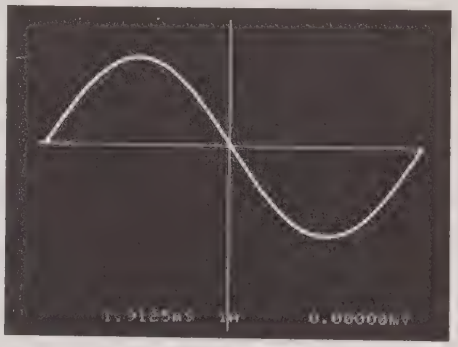


*Figure 8-14*

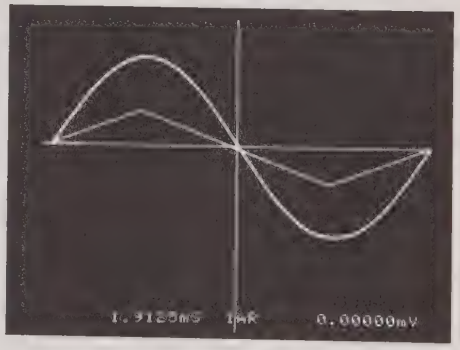


*Figure 8-15*

*EXAMPLE #8-4*

*Figure 8-14: Typical signal acquired with SAVE REFERENCE turned off.*

*Figure 8-15: Resulting display of the altered signal superposed over the original signal when the SAVE REFERENCE switch was turned on.*

## AVERAGE SWITCH

Reduces the effects of "noise" on recurrent input signals by "sweep" averaging successive sweeps.

To function properly, the input signal must be time-locked to an associated trigger signal.

The sampling rate is determined by the selected Time-Per-Point.

Sample voltages acquired during the first sweep are stored in the memory. Then, samples acquired during the second sweep are averaged with those acquired during the first sweep. Each "newer" average, computed from Equation 8-2, updates the memory.

This process of averaging "new" samples with the "old" averages stored in the memory repeats for each sweep.

$$SV_{ave} = Old \times \frac{(K-1)}{K} + \frac{New}{K}$$

*Equation 8-2*

- (Old): The average voltage value currently stored in the memory's address.
- (New): The newest sampled voltage acquired during the current sweep.
- (K): The values tabulated in Table 8-6, corresponding to the sweep in progress.

| SWEEP | 1 | 2 | 3-5 | 6-10 | 11-21 |
|---|---|---|---|---|---|
| K | *1* | *2* | *4* | *8* | *16* |

*Table 8-6*

The term "K" is computed from Equation 8-3. The result is rounded off to the nearest, lower power of two, $(2^n)$.

$$K = Sweep + \frac{Sweep}{2}$$

*Equation 8-3*

NOTE: This type of averaging is called virtual averaging and is similar to "true" or normalized averaging. However, unlike normalized averaging, virtual averaging "weights" each sweep differently because of the use of binary number "K" instead of "N" (Number of Sweeps). If the variations in voltages, from sweep to sweep, are due entirely to "noise" and not because of signal changes, the result is identical.

*EXAMPLE #8-5*

*Figure 8-16: First sweep sampled at 1V1, 1V2, .... $1V_x$.*

*Figure 8-17: Second sweep sampled at 2V1, 2V2, .... $2V_x$.*

*Figure 8-18: Third sweep sampled at 3V1, 3V2, .... $3V_x$.*

*If -*

*1V1 = 8V, 2V1 = 10V, and 3V1 = 8V, the average value of the first data point displayed ($AV_1$, $AV_2$, $AV_3$) during each of the three sweeps equals:*

$$AV_1 = 0V \times \frac{(1-1)}{1} + \frac{8V}{1} = 8V$$

$$AV_2 = 8V \times \frac{(2-1)}{2} + \frac{10V}{2} = 9V$$

$$AV_3 = 9V \times \frac{(4-1)}{4} + \frac{8V}{4} = 8.75V$$

*Figure 8-19: The upper display illustrates a "noisy" signal acquired without the Average mode.*

*The lower display illustrates, after several sweeps, the same "noisy" signal captured with the Average mode.*

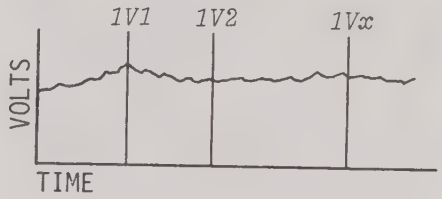



*Figure 8-16*

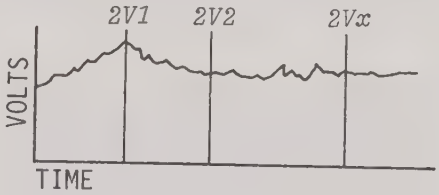



*Figure 8-17*

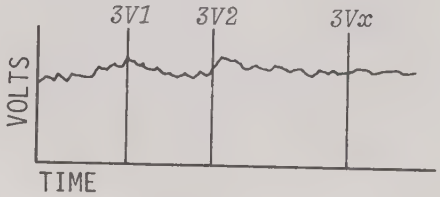



*Figure 8-18*

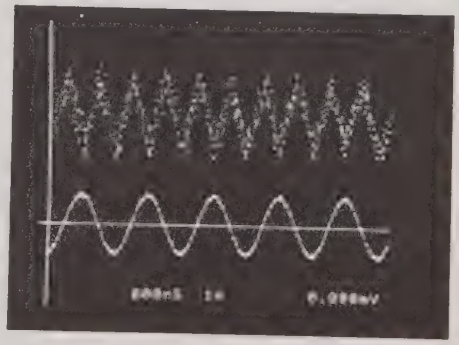


*Figure 8-19*

## POINT AVERAGE SWITCH

Reduces the effects of "noise" on an input signal acquired when the time-per-point is slower than 500 microseconds.

The oscilloscope acquires data at a constant rate of 250 microseconds per sample. As each sample is acquired, it is averaged with the preceding samples within the same sampling period (time-per-point setting).

For example, an average is computed from the values of the first and second samples which, in turn, is averaged with the value of the third sample, etc.

When the last sample within the string has been averaged, the final averaged value is stored in one of the memory's addresses and displayed by a single data point coordinate.

This process repeats until each one of the memory's allotted addresses has recorded an average value.

The point average values are computed by Equation 8-4.

$$PV_{ave} = Old \times \frac{(K-1)}{K} + \frac{New}{K}$$

*Equation 8-4*

- (Old): The average voltage value currently stored in the memory's address.
- (New): The newest sampled voltage acquired within the string.
- (K): The values tabulated in Table 8-7, corresponding to the sample being acquired.

| SAMPLE | 1 | 2 | 3-5 | 6-10 | 11-21 |
|---|---|---|---|---|---|
| K | *1* | *2* | *4* | *8* | *16* |

*Table 8-7*

The term "K" is computed from Equation 8-5. The result is rounded off to the nearest, lower power of two, $(2^n)$.

$$K = Sample + \frac{Sample}{2}$$

*Equation 8-5*

*EXAMPLE #8-6*

*Assume that a string of three samples will be point averaged for each data point coordinate.*

*Figure 8-20: The first string sampled at 1V1, 1V2, and 1V3 for the first data point to be displayed in the sweep. (Sample 2V1 starts the second string of samples for the second data point.)*

*If-*
*1V1 = 6V, 1V2 = 8V, and 1V3 = 4V, the average voltage value of the first data point to be displayed in the sweep will equal 6.25 volts.*

*Where -*

$$PV_1 = 0V \times \frac{(1-1)}{1} + \frac{6V}{1} = 6V$$

$$PV_2 = 6V \times \frac{(2-1)}{2} + \frac{8V}{2} = 7V$$

$$PV_3 = 7V \times \frac{(4-1)}{4} + \frac{4V}{4} = 6.25V$$

*Figure 8-21: The upper display illustrates a "noisy" signal acquired without the Point Average mode.*

*The lower display illustrates, after one sweep, the same "noisy" signal captured with the Point Average mode.*

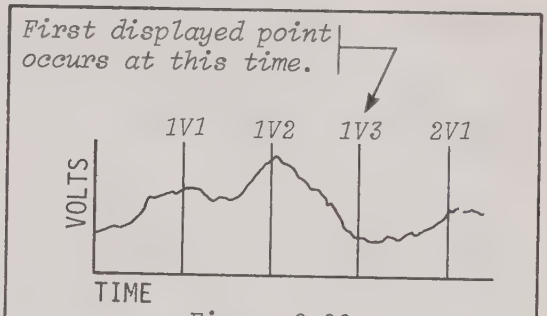



*Figure 8-20*

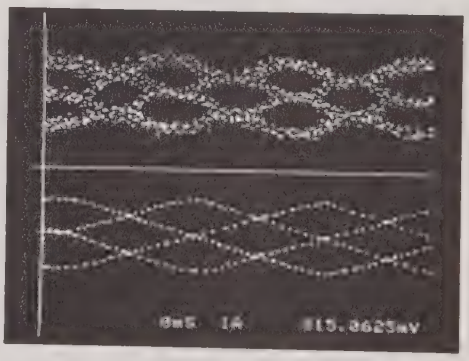


*Figure 8-21*

● COMBINING AVERAGE & POINT AVERAGE

The "sweep" Average and Point Average modes of operation can be combined if the time-per-point is slower than 500 microseconds. The effectiveness of averaging very "noisy,' repetitive signals is enhanced when both of these modes are combined.

Essentially, Point Averaged values acquired during the first sweep are recorded in the memory's addresses. Then, as each "new" Point Averaged value is acquired in the second sweep, it is "sweep" Averaged with the corresponding value stored in the memory. The resulting average values continually replace the "older" values stored in the memory.

This process of "sweep" Averaging the "older" values stored in the memory with the "newer" Point Averaged values acquired during the current sweep repeats with every sweep, providing additional improvements in the signal to noise ratio.

The FILTER switch can also be used in conjunction with the Average and/or Point Average mode of operation.

## SOURCE SWITCH

Selects whether the triggers will be derived from either the channel A or channel B amplifiers, or through the EXT input BNC.

- EXT

Selected when the trigger is applied to the EXT input BNC, enabling a common trigger to simultaneously initiate sweeps on both channels.

The amplitude of the signal must be 400 mV (minimum) to qualify as a valid trigger.

- A or B

Selected to allow amplification of the signal before it enters the trigger detection circuits. The signal must be at least 2% of the selected Volts Full Scale to qualify as a valid trigger.

NOTE: A valid trigger applied to channel A will also initiate a sweep on channel B if the CHANNEL B "ON/OFF" switch is turned on. The opposite is true when a trigger is applied to CHANNEL B.

- S

Selected when multiple Plug-ins will be triggered by a common signal.

The trigger must be applied to the "Master" Plug-in and the position selected on that Plug-in's SOURCE switch (A, B, or EXT) must correspond accordingly.

The remaining Plug-in(s) are referred to as the Slave Plug-ins. The SOURCE switch(es) must be placed to the "S" position.

A trigger applied to the Master Plug-in will also trigger a sweep at the Slave Plug-ins.

## AUTO/NORM SWITCH

Determines whether the trigger will be generated internally in the absence of a valid trigger signal or solely by an external source.

- AUTO

Automatically triggers in the absence of a valid trigger.

- NORM

The trigger is externally generated. The next valid trigger to occur, after the preceding sweep has been completed, will initiate a new sweep.

## COUPLING SWITCH

Determines whether or not a dc component on the triggering signal being applied to the EXT input BNC will be attenuated.

- AC

Signals are capacitively coupled to the trigger detection circuit. DC components of approximately 2 hertz, or less, are attenuated while the ac component is allowed to pass.

- DC

Both ac and dc components of the signal are coupled to the trigger detection circuitry.

## VIEW SWITCH

►IMPORTANT: Displayed data will be erased from the display memory when the VIEW switch is turned on. Precautions must be taken if the displayed data is to be saved. (Such as recording the data on a diskette or placing the MEMORY switch to an empty, or unimportant, "halves" or "quarters" position.) In addition, the View mode will override the Save Reference mode and the functions of the TRIG POSITION controls.

Two horizontal lines appear and the Plug-in's Trigger cursor moves to screen center when VIEW is selected and the Plug-in is operating in the Live mode with sweeps occurring. A letter "V" suffix will be added to the Plug-in/Channel numerics, (e.g., 1AV). If external triggering is selected, the Plug-in number will be followed by an "EV" suffix, (e.g., 1EV).

The configuration and position of the two lines indicate the slope (page 8-31), minimum amplitude (page 8-32), and minimum voltage change (page 8-33) that the signal must experience to qualify as a valid trigger. All three characteristics must be met by the signal before a sweep will be initiated.

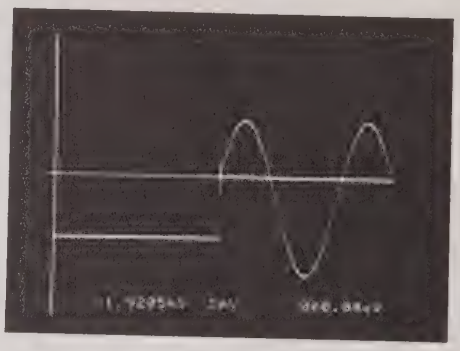


*Figure 8-22*

To use the VIEW mode:

#1. Take precautions to save any important data stored in the display memory.

#2. If any of the Plug-in's controls must be repositioned, place the Plug-in into the Hold mode, or press the LIVE button after the controls have been repositioned.

#3. AUTO/NORM switch: As required.

#4. VIEW switch: On

#5. LIVE button: Press.

*EXAMPLE #8-7*

*Figure 8-22: Typical VIEW display with Positive Slope selected.*

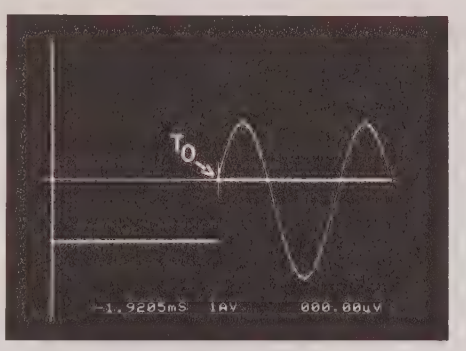



*Figure 8-23*

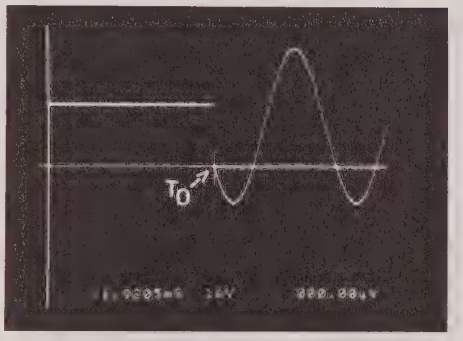



*Figure 8-24*

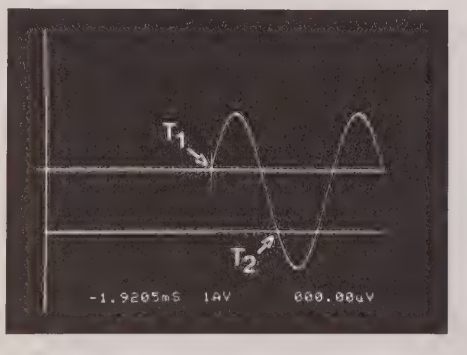



*Figure 8-25*

## SLOPE SWITCH

►NOTE: See IMPORTANT note on page 8-30 before turning on VIEW switch

Determines whether positive and/or negative going voltage transitions will qualify the signal as a trigger.

● (+) Slope
The signal voltage must be increasing.

● (-) Slope
The signal voltage must be decreasing.

● DUAL Slope
Either increasing or decreasing voltage values will qualify the signal.

*EXAMPLE #8-8*

*Figure 8-23: (+) slope display. Signal qualifies as a valid trigger component at point ($T_0$).*

*Figure 8-24: (-) slope display. Signal qualifies as a valid trigger component at point ($T_0$).*

*Figure 8-25: DUAL slope display. Signal qualifies as a valid trigger at either point ($T_1$) or ($T_2$).*

## LEVEL CONTROL

►NOTE: See IMPORTANT note on page 8-30 before turning on VIEW switch

The LEVEL control adjusts the threshold levels which, when crossed by the signal, will qualify the signal as a valid trigger component.

Which of the two lines must be crossed by the signal is a function of the SLOPE switch.

- (+) - The signal must cross the upper threshold level.
- (-) - The signal must cross the lower threshold level.
- DUAL - The signal can cross either threshold level.

*EXAMPLE #8-9*

*Figure 8-26: A (+) slope display. Signal qualifies as a valid trigger component at point ($T_0$).*

*Figure 8-27: A (-) slope display. Signal qualifies as a valid trigger component at point ($T_0$).*

*Figure 8-28: A DUAL slope display. Signal qualifies as a valid trigger at either point ($T_1$) or ($T_2$).*

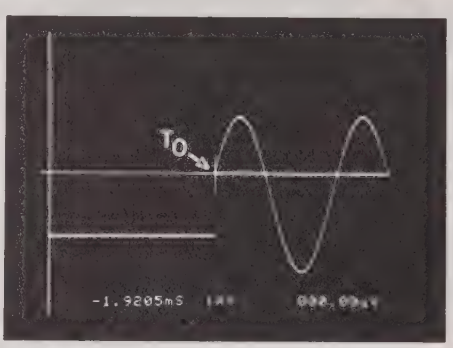



*Figure 8-26*

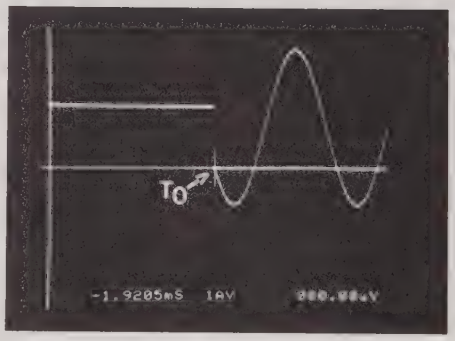



*Figure 8-27*

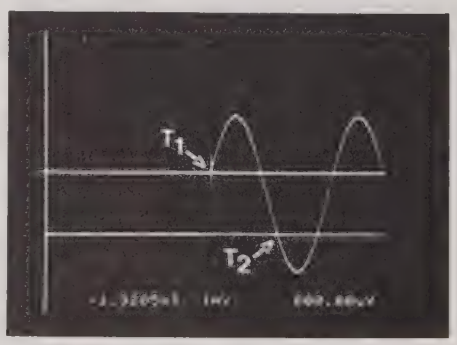



*Figure 8-28*

## SENSITIVITY CONTROL

►NOTE: See IMPORTANT note on page 8-30 before turning on VIEW switch

Adjusts the distance (window) between the two threshold levels. This "window" must be crossed by the signal in order to qualify as a valid trigger component when either (+) or (-) slope triggering is selected.

The "window" voltage can be adjusted from a range of 400 millivolts to 18 volts when triggering via the EXT input BNC. And from 2% to 90% of the Volts Full Scale when triggering via the channel A or B amplifiers.

The voltage numerics will alternate between the voltage values of the upper and lower threshold levels when the vertical cursor is moved across the display screen with Autocenter turned on.

*EXAMPLE #8-10*

*Figure 8-29: "Window" voltage (Vab) equals the difference between the upper limit (Va) and lower limit (Vb) voltage values.*

*Figure 8-30: The dashed lines on the second positive-going slope indicates an amplitude of sufficient size to qualify the signal as a valid trigger component.*

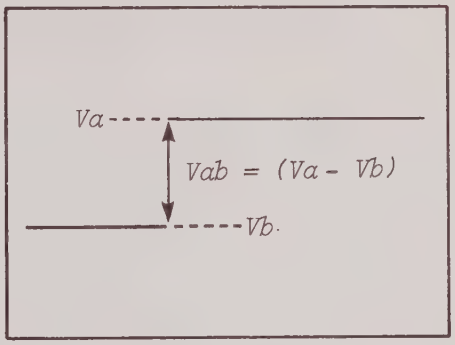



*Figure 8-29*

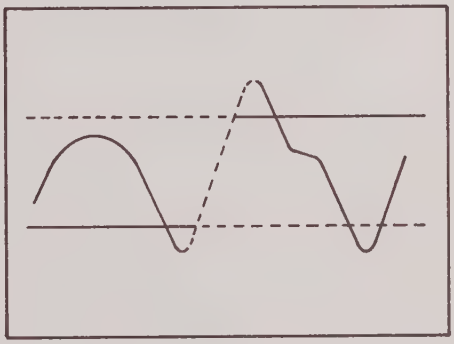


*Figure 8-30*

## RECURRENT TRIGGERING

- (+) or (-) SLOPE TRIGGERING

After the first trigger has been initiated, the signal's slope must reverse, pass through the "window," reverse again, and then pass through the "window" once more in order to initiate another trigger.

*EXAMPLE #8-11*

*Assume (+) Slope triggering has been selected and the VIEW switch is on.*

*Figure 8-31: The first positive slope (solid line) starts below the lower threshold level, passes through the "window," and initiates a trigger at point ($T_1$). The dashed lines represent the path that the signal must follow in order to initiate a second trigger at point ($T_2$).*

*Figure 8-32: Once again, the signal qualifies as a trigger at point ($T_1$). Since the second positive slope did not start below the lower threshold, a trigger will not occur at point (A). It will, however, occur at point ($T_2$) because the positive slope begins below the lower threshold.*

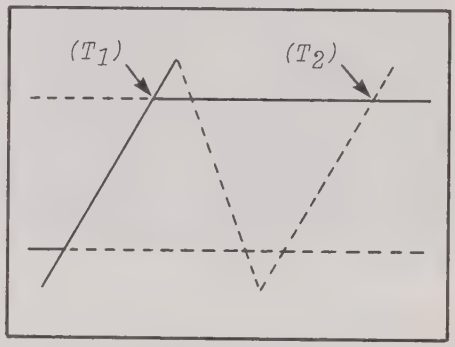



*Figure 8-31*

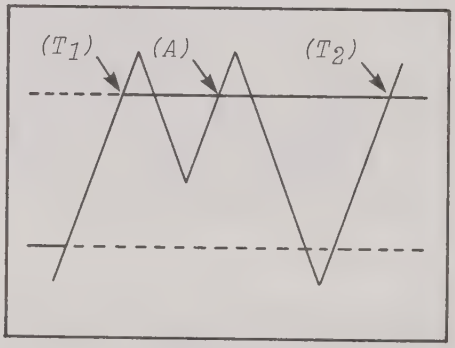



*Figure 8-32*

● DUAL SLOPE TRIGGERING

Recurrent triggers will be initiated each time the signal crosses either threshold level with the proper slope. The signal does not have to recross through the "window."

NOTE: The signal must experience a voltage change of 2% (minimum) of the selected Volts Full Scale to qualify as a valid trigger.

*EXAMPLE #8-12*

*Assume "DUAL" slope triggering has been selected on the SLOPE switch and the VIEW switch is on.*

*Figure 8-33: Valid triggers will occur at points ($T_1$ thru $T_4$) because the signal crosses the threshold levels with the correct slopes.*

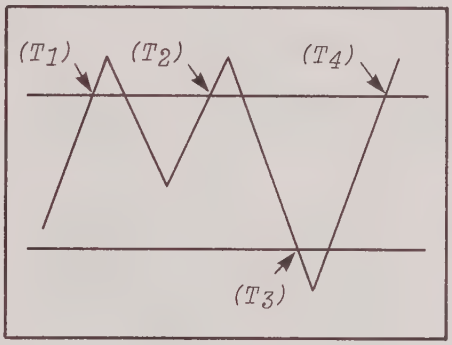



*Figure 8-33*

## ADJUSTING THE TRIGGER

- (+) or (-) SLOPE TRIGGERING

#1. SLOPE: (+) or (-)

#2. AUTO/NORM: Auto

#3. COUPLING: As required.

#4. VIEW: On

#5. Trigger: Apply to EXT input BNC or to one of the channels.

#6. SOURCE: As required.

#7. DC/AC/GND: As required.

#8. LIVE: Press.

#9. POSITION: Adjust display for best placement.

#10. VOLTS FULL SCALE: As required.

#11. SENSITIVITY: Full counterclockwise. Then adjust clockwise until the "window" exceeds any "noise" spikes.

#12. LEVEL: Adjust until the upper threshold (+ slope) or lower threshold (- slope) intersects the desired trigger point.

#13. Fine tune the SENSITIVITY and LEVEL controls as required.

#14. After the SENSITIVITY and LEVEL controls have been properly positioned, place the AUTO/NORM switch to the "NORM" position. The Plug-in will continue to trigger.

NOTE: The TRIGGER light illuminates when a valid trigger is received and remains illuminated until the sweep is completed.

- DUAL SLOPE TRIGGERING

#1. SLOPE: Dual

#2. AUTO/NORM: Auto

#3. COUPLING: As required.

#4. VIEW: On

#5. Trigger: Apply to EXT input BNC or to one of the channels.

#6. SOURCE: As required.

#7. DC/AC/GND: As required.

#8. LIVE: Press.

#9. POSITION: Adjust display for best placement on screen.

#10. VOLTS FULL SCALE: As required.

#11. SENSITIVITY: Full counter-clockwise.

#12. LEVEL: Adjust until "window" is centered between the desired positive and negative trigger points.

#13. SENSITIVITY: Adjust until the upper and lower threshold levels intersect the desired positive and negative trigger points.

#14. Fine tune the LEVEL and SENSITIVITY controls as required.

#15. After the SENSITIVITY and LEVEL controls have been properly positioned, place the AUTO/NORM switch to the "NORM" position. The Plug-in will continue to trigger.

NOTE: The TRIGGER light illuminates when a valid trigger is received and remains illuminated until the sweep is completed.

## TRIGGER POSITION CONTROLS

The TRIG POSITION controls consist of a ZERO button (common to both channels), paddle "A" (channel A only), and paddle "B" (channel B only).

These controls select whether post-trigger (Normal), pre- and post-trigger (Cursor), or delayed trigger (Delayed) events will be displayed.

NOTE: These can be mixed or matched in multiple channel operation. Refer to *Special Procedures* tab, page 15-5.

- LIVE MODE (Coarse Adjust)

Pressing the paddle control causes the Trigger cursor to move 1/8 of full screen at the end of each sweep.

- LIVE MODE (High Speed Adjust)

Pressing, and holding, the LIVE button and paddle control causes a high speed movement of the Trigger cursor.

- SET-UP MODE (Fine Adjust)

Initiated by simultaneously pressing the HOLD LAST and HOLD NEXT buttons, illuminating all three STORAGE control LEDs. NOTE: ENSURE THAT THE HOLD LAST BUTTON IS RELEASED FIRST. The trigger's rate of movement increases the longer the paddle is pressed. Releasing and then repressing the paddle returns the advance to a slower rate of movement. The letter "S" suffix is added to the Plug-in/Channel numerics, (i.e., 1AS), when the Set-up mode is selected.

► IMPORTANT: OPERATING THE PADDLE CONTROLS, OR ZERO BUTTON, IN THE "SET-UP" MODE ALTERS THE ($T_0$) ORIGIN, CAUSING THE TIME NUMERICS TO BECOME ERRONEOUS. The "set-up" mode can be exited by pressing either the HOLD LAST or LIVE button. However, the time numerics will remain erroneous until a new sweep is acquired.

*EXAMPLE #8-13*

*Figure 8-34: The types of triggers and related sweeps during which data is acquired for display.*

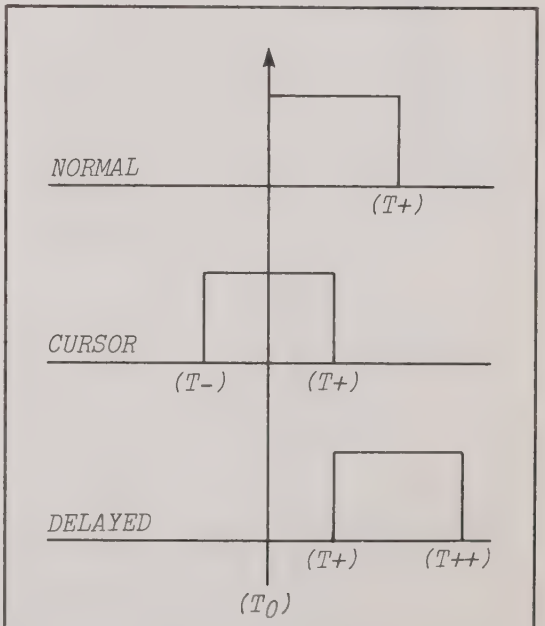



*Figure 8-34*

● NORMAL TRIGGER DISPLAY

The oscilloscope immediately resets to the Normal Trigger mode when the ZERO button is pressed and the Plug-in is operating in the "set-up" mode. If the Plug-in is operating in the LIVE mode, valid triggers must be occurring while the ZERO button is pressed, since the "reset" command will not be recognized until the end of a sweep.

If the Plug-in is operating in the LIVE mode and -

#1. a long sweep is in progress, or

#2. no triggers are occurring, or

#3. a long delay has been selected,

then, to quickly reset the delay to zero, hold the ZERO button in and momentarily press the LIVE button.

The Plug-in's Trigger cursor is positioned at the extreme left-hand side of the screen when the oscilloscope is operating in the Normal Trigger mode. Only those events occurring after a valid trigger will be displayed on the screen.

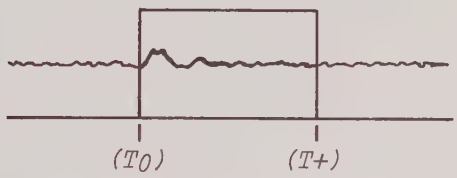



*Figure 8-35*

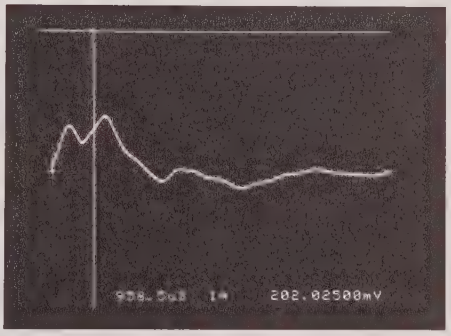



*Figure 8-36*

*EXAMPLE #8-14*

*Figure 8-35: A typical input signal.*

*The boxed area represents one complete sweep starting at point ($T_0$), the trigger, and ending at point (T+).*

*Figure 8-36: The corresponding Normal trigger display of the signal captured during the sweep.*

● CURSOR TRIGGER DISPLAY

The oscilloscope enters the Cursor Trigger mode when the TRIG POSITION paddle is pressed to the right and the Plug-in is operating in the "set-up" mode. If the Plug-in is operating in the LIVE mode, valid triggers must be occurring while the ZERO button is pressed.

NOTE: If the Plug-in is in the LIVE mode and a long sweep is in progress, the Cursor Trigger command may not be acknowledged until the next sweep is initiated. (The TRIG POSITION paddle must be pressed towards the right as the new sweep is initiated.)

The Plug-in's Trigger cursor will reposition towards the right-hand side of the screen, stopping when the paddle is released. Pre-trigger events will be displayed to the left of the trigger cursor. Post-trigger events will be displayed to the right of it.

Essentially, data is continually being sampled and stored in the memory. When a valid trigger is received, the pre-trigger events are stored in the memory and the post-trigger events fill the remaining memory addresses.

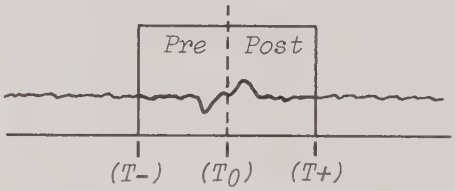



*Figure 8-37*

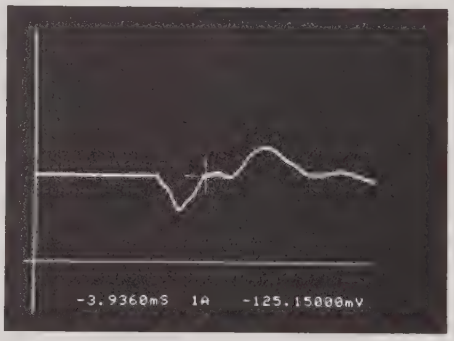



*Figure 8-38*

*EXAMPLE #8-15*

*Figure 8-37: A typical input signal. The boxed area represents one complete sweep starting at point (T-) and ending at point (T+). Point ($T_0$), the trigger, "locks" the pre-trigger data in the memory's addresses. The remaining addresses will record the post-trigger data.*

*Figure 8-38: The corresponding display of the captured input signal.*

● DELAYED TRIGGER DISPLAY

NOTE: Reposition the Mainframe's vertical cursor to the extreme left-hand side of the screen before activating the Delayed Trigger mode.

The oscilloscope enters the Delayed Trigger mode when the TRIG POSITION paddle is pressed to the left and the Plug-in is operating in the "set-up" mode. If the Plug-in is operating in the LIVE mode, valid triggers must be occurring while the ZERO button is pressed.

NOTE: If the Plug-in is in the LIVE mode and a long sweep is in progress, the Delayed Trigger command may not be acknowledged until the next sweep is initiated. (The TRIG POSITION paddle must be pressed towards the left when the new sweep is initiated.)

The Plug-in's Trigger cursor (time zero) repositions to the left and continues to reposition off the left of screen. The time delay, indicated by the time numerics, reflects the time difference between the "positions" of the Trigger cursor and the vertical cursor.

Equation 8-6 computes the maximum time delay ($T_{max}$) that can be selected.

$$T_{max} \approx \frac{2^{24} \times (TPP)}{(Channels) \times (Memory)}$$

*Equation 8-6*

- (TPP): Time-per-point selection.
- (Channels): The number of channels turned on.
- (Memory): The position selected on the MEMORY switch. "ALL" = 1, "Halves" = 2, and "Quarters" = 4.

The Mainframe's vertical cursor can be repositioned after the delay has been set to inspect specific data point coordinates.

NOTE: Sometimes a very long delay may be inadvertently selected in the Delayed trigger mode of operation. To quickly clear the delay, hold the ZERO button in and momentarily press the LIVE pushbutton.

*EXAMPLE #8-16*

*Figure 8-39: A typical input signal applied to an input BNC.*

*Point ($T_0$) indicates the point at which a valid trigger initiated the time delay.*

*The boxed area represents one complete sweep, starting at Point (T+) which represents the end of the time delay. Point (T++) represents the end of the sweep, during which time data was acquired for display.*

*Figure 8-40: The corresponding Delayed trigger display of the signal captured during the sweep.*

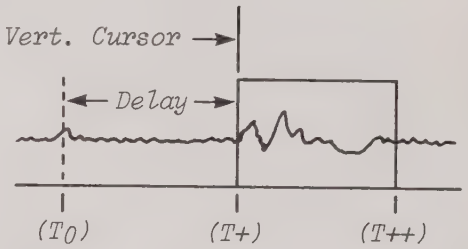



*Figure 8-39*

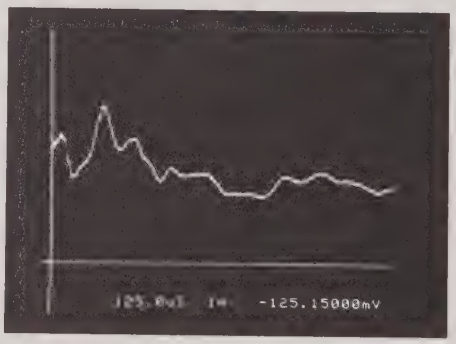



*Figure 8-40*

## REMOTE CONTROL CONNECTOR

Events can occur so rapidly that the operator's reaction time is not fast enough to capture them.

This problem can be resolved by simulating certain commands with external sensors possessing the required reaction times.

Figure 8-41 identifies the function of each pin.

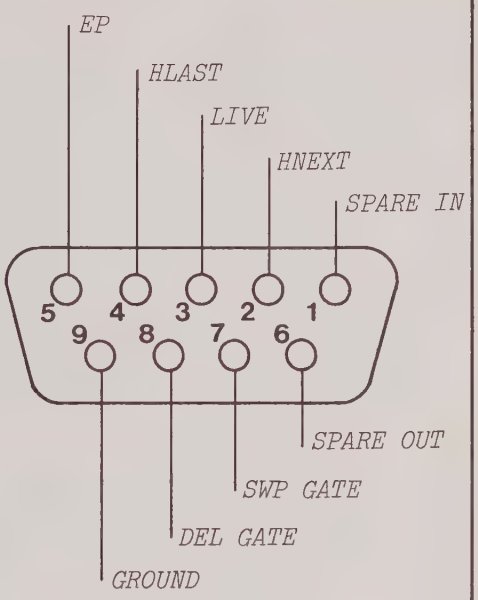



*Figure 8-41*

- HOLD LAST, LIVE and HOLD NEXT

The Storage Control buttons can be simulated by shorting the corresponding pins to ground through a low resistance contact or with an open collector TTL gate.

NOTE: Use the ground provided by Pin 9 on the Remote Control Connector.

- EP

The EP input is used to advance the memory to its next address when the TIME PER POINT switch is in either the EXT I or II positions.

The EP input should normally rest at less than 0.4 volts and then be raised to more than 3 volts DC each time the memory is to advance one address.
The "EP" input is TTL compatible.

● DEL GATE

The Delayed Gate output activates when either channel receives a valid trigger.

The output normally rests at 0.4 volts and rises to +3 VDC immediately following the valid trigger. It will return to 0.4 volts as soon as the sweep has been completed.

Figure 8-42 illustrates the three types of triggers and corresponding sweeps and Delayed Gate outputs.

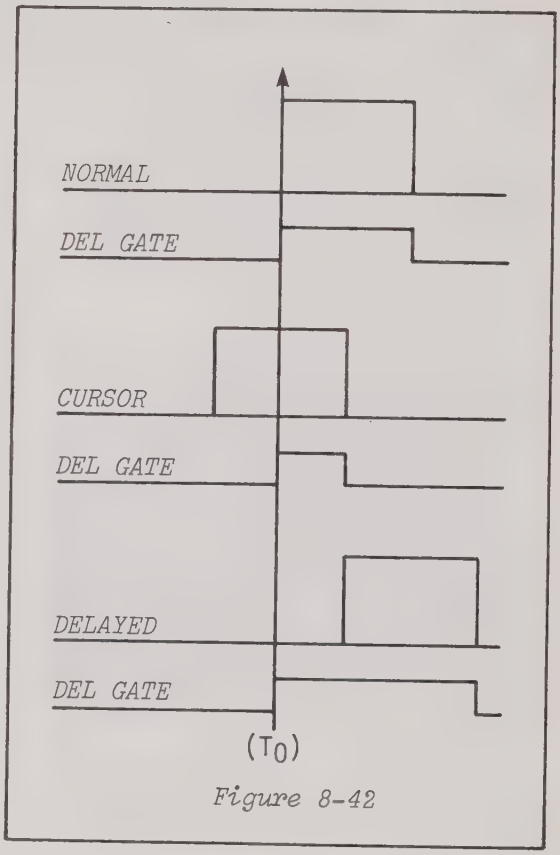



*Figure 8-42*

● SWP GATE

The Sweep Gate output is activated only during valid data point collection.

The output normally rests at 0.4 volts and rises to +3 VDC when a sweep is in progress.

● SPARE IN/SPARE OUT

Not currently being used.

## PROBE POWER CONNECTOR

A ±12 VDC output voltage, with a maximum current of 100 ma, is available from the Probe Power connector.

The voltage polarities and ground are identified in Figure 8-43.

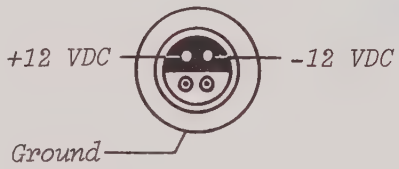



*Figure 8-43*

## COMPENSATION POINT

Touching the test probe to the COMP point produces a square-wave on the screen.

►IMPORTANT: The Time Per Point must be 20 µSeconds or faster.

Compensate the test probe for the best response time (rise and fall times) on the square-wave display.

*EXAMPLE #8-17*

*Figure 8-44 illustrates a square-wave displayed with expansion applied.*

*The top square-wave was produced from an uncompensated probe. The bottom square-wave was produced after the test probe was properly compensated.*

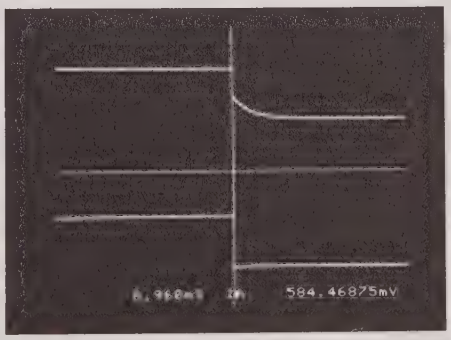
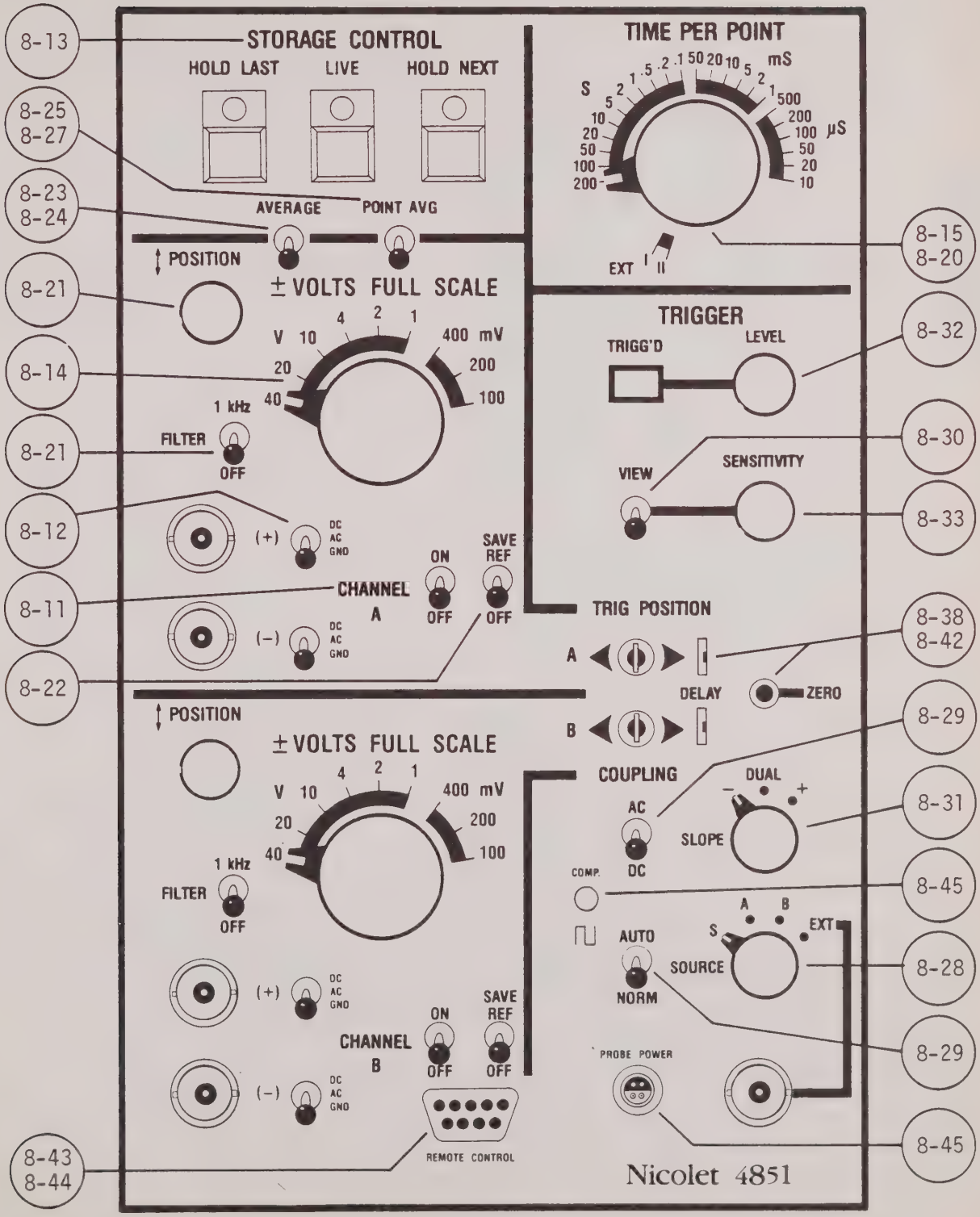



*Figure 8-44*

# Model 4851 Plug-in



## INTRODUCTION

The Model 4851, two channel Plug-in includes two high impedance, differential amplifiers; two 15-bit, 100 kHz digitizers; and a single 16K word memory.

Other features include -

- Single-ended or differential amplifiers.
- Positive, negative, or dual slope triggering.
- Normal, Pre- and Post-trigger, and Delayed trigger displays.
- A Trigger View mode to assist in the selection of the trigger's qualifying characteristics.
- Sweep Averaging, Point Averaging, and 1 kHz Filter to reduce the effects of "noise" on the signals.
- A Save Reference mode to compare "live" and saved signals.
- Remote control abilities.
- Test point compensation.
- A ±12 VDC probe power output.

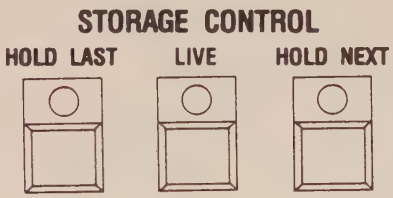
►IMPORTANT: The term "Hold mode," in the following discussions, signifies that the Plug-in's HOLD LAST LED is illuminated only. The Live and Hold Next LEDS are turned off.

The Plug-in should be in the Hold mode whenever a Plug-in parameter is changed. Otherwise, the operator must either press the LIVE button to reset the Plug-in, or wait until after the next sweep is completed before the 4094 will acknowledge the parameter change(s).

The Plug-in is in the Hold mode when only the Hold Last LED is illuminated. If a sweep is not in progress, the Hold mode can be selected by pressing the HOLD LAST button. If, however, a sweep is currently in progress, the Hold mode can be selected by:

#1. HOLD LAST button: Press and hold.
#2. LIVE button: Press momentarily.
#3. HOLD LAST button: Release.

NOTE: The following descriptions are for single Plug-in operation only. Refer to the *Multiple Plug-ins* tab, after reading this section of the manual, for additional information.



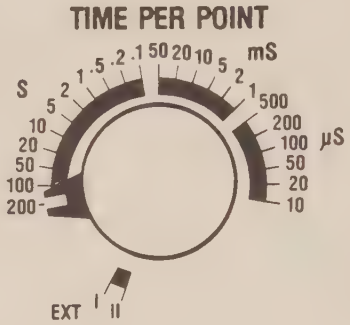
## STORAGE CONTROL BUTTONS

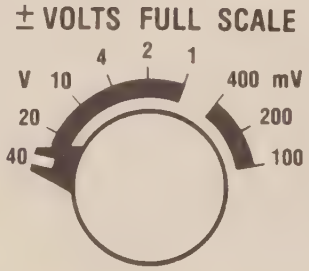
The Storage Control buttons determine whether the displayed data groups will remain "live" or be stored in the display memory.

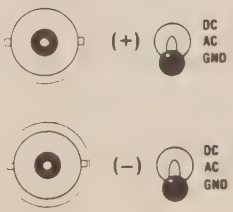
- LIVE - New signals are acquired and displayed on the screen each time a valid trigger is received.
- HOLD NEXT - The signal following the next valid trigger is stored in the display memory and displayed on the screen.
- HOLD LAST - The signal that followed the last valid trigger is stored in the display memory and displayed on the screen; including a signal already in progress at the moment the button is pressed.

## CHANNEL SWITCH

The "ON" position allows the display memory to record data acquired by the associated channel and display it on the screen.




## TIME PER POINT

Selects the time resolution of the signal to be acquired.

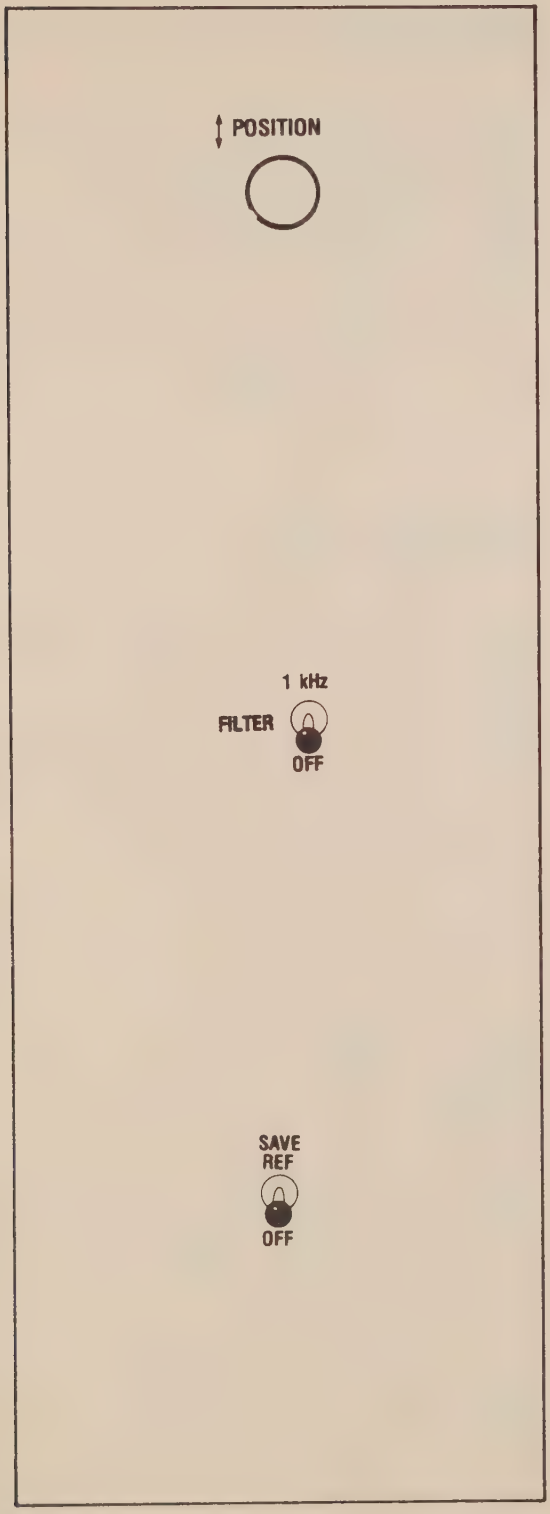
Sweep speeds are expressed as time-per-point rather than time-per-centimeter.

## ± VOLTS FULL SCALE SWITCH

Allows the oscilloscope to accept input signals ranging from ±100 millivolts to ±40 volts full scale.

## DC/AC/GND SWITCH

- GND - Grounds the amplifier's input.
- DC - Allows both ac and dc signal components to enter the amplifier.
- AC - Blocks the dc component. Allows only the ac component to enter the amplifier.




## POSITION CONTROL

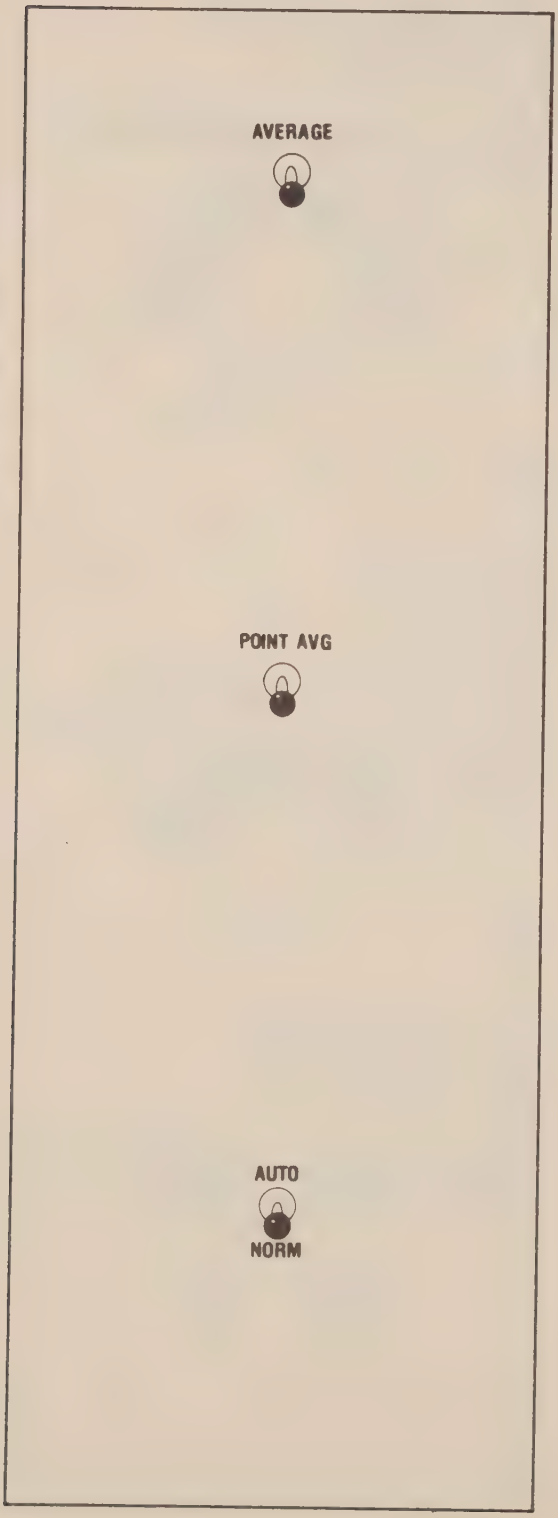
Vertically positions the displayed signal on the screen.

## FILTER SWITCH

Filters high frequency "noise" components to ground. Used with low frequency input signals.

## SAVE REFERENCE SWITCH

Allows the operator to compare "live" and saved signals in the Live mode.




## AVERAGE SWITCH

Reduces "noise" on recurrent signals by averaging (from sweep to sweep) sampled voltages acquired equidistant with respect to each trigger, (T=0).

## POINT AVERAGE SWITCH

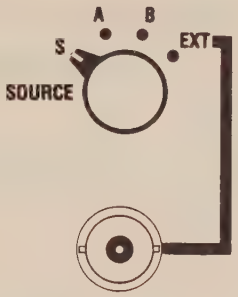
Reduces "noise" on single sweep input signals when the time-per-point is greater than *** µS by averaging the input signal at a constant sampling rate of *** µS/point between each displayed data point.

## AUTO/NORM SWITCH

Determines whether the trigger will be generated internally in the absence of a valid trigger signal or by an external input signal.

- AUTO - Internally triggered.
- NORM - Externally triggered.

*Exact spec's to be verified.*




## TRIGGER SOURCE SWITCH

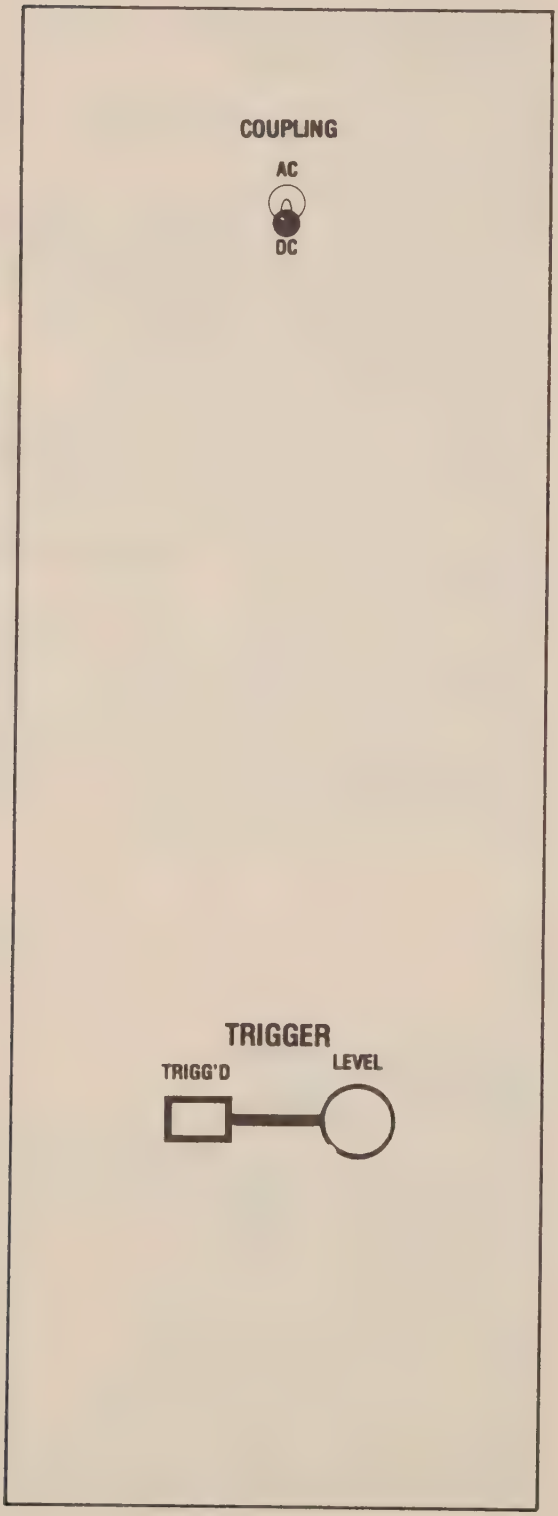
Selects the source of the input trigger signal.

- (S) - "Slave," trigger comes from the "master" Plug-in when multiple Plug-ins are being triggered from a common source. The "master" Plug-in's switch must be in the (A), (B), or (EXT) positions. The "slave" Plug-in(s) must be in the (S) position.
- (A) - Trigger signal is derived from channel A.
- (B) - Trigger signal is derived from channel B.
- EXT - Trigger signal is derived from the EXT input BNC.

## TRIGGER SLOPE SWITCH

Selects the signal's voltage transitions that will qualify it as a valid trigger.

- (+) - Positive-going only.
- (-) - Negative-going only.
- DUAL - Either positive- or negative-going voltage transitions.




## TRIGGER COUPLING SWITCH

Determines whether or not the dc component of the input signal will be blocked.

- AC - Only the ac component of the signal is applied to the trigger circuit. The dc component is blocked.
- DC - All frequency components of the input signal are applied to the trigger circuit. Used when low frequency input signals are to be inspected or the dc component is of importance.

## TRIGGER LEVEL CONTROL & TRIGG'D LED

Adjusts the voltage level that must be crossed by the triggering signal to qualify as a valid trigger.

The green LED indicator illuminates each time a valid trigger initiates a sweep.

## TRIGGER POSITION CONTROLS

Selects whether the screen will display post-trigger events (Normal Trigger), both pre- and post-trigger events (Cursor Trigger), or events that occurred following a specific time delay (Delayed Trigger).

- Normal Trigger - Press the Zero button.
- Cursor Trigger - Press the paddle switch to the right.
- Delayed Trigger - Press the paddle switch to the left.

The adjacent LED indicator(s) illuminate when either Cursor or Delayed Trigger modes are selected.

## TRIGGER SENSITIVITY & VIEW CONTROLS

The Trigger SENSITIVITY control adjusts the "window" (voltage span) that the signal must pass through before it will qualify as a valid trigger.

The VIEW switch, when turned on, introduces a "trigger adjust" display. This display assists the operator in the selection of specific characteristics that will qualify the signal as a valid trigger.

## COMPENSATION POINT

Placing the test probe against the compensation point produces a square-wave display. This display assists the operator in the compensation of the test probe for the best response times.

## PROBE POWER CONNECTOR

Provides a +12 and/or -12 VDC output.

## REMOTE CONTROL CONNECTOR

Permits remote control of the Plug-in.

## CHANNEL SWITCHES

The display memory will not store data unless the ON/OFF switch associated with the channel acquiring data is placed to the "ON" position.

For example, the CHANNEL A switch must be in the "ON" position if channel A is acquiring input signals.

If only one channel (typically channel A) is being used to acquire input signals, turn the unused channel off. This allows the entire display memory of 15,872 addresses to record data if the Mainframe's MEMORY switch is in the "ALL" position.

The number of addresses that will record each input signal depends upon the positions of the CHANNEL and MEMORY switches. Table 8-1 tabulates the number of addresses that will record each input signal.

NOTE: Table 8-1 is for single Plug-in operation only.

| CHANNEL SWITCH | | MEMORY SWITCH POSITION | | |
|---|---|---|---|---|
| A | B | ALL | HALVES | QUARTERS |
| ON | OFF | *15,872* | *7,936* | *3,968* |
| OFF | ON | *15,872* | *7,936* | *3,968* |
| ON | ON | *7,936* | *3,968* | *1,984* |

*Table 8-1*

## DC/AC/GND SWITCHES

This instrument uses high impedance, differential amplifiers. The high impedances ($10^6$ ohms) and low bias currents ($10^{-10}$ amps) allow high impedance signal sources to be measured because of the light loading effect of the amplifiers.

The DC/AC/GND switches control the operation of the associated amplifiers' inputs.

> CAUTION - Always ensure that the input signals never exceed the maximum, allowable input voltage, with respect to ground, listed under tab *Specifications*.

- DC
  Allows both ac and dc components of the input signal to enter the amplifier.
- AC
  Blocks the dc component. Only the ac component of the signal enters the amplifier.
- GND
  Grounds the amplifier's input. Neither ac nor dc components will enter the amplifier.

NOTE: Always ground an unused amplifier input by placing the associated DC/AC/GND switch to the "GND" position. An ungrounded, unused input will introduce "noise."

Each of the amplifiers can be used as either Differential or Single-ended amplifiers.

- DIFFERENTIAL AMPLIFIERS

Placing the channel's DC/AC/GND switches to either the "DC" or "AC" position allows the amplifier to measure the difference between the voltages applied to the (+) and (-) input BNCs.

- SINGLE-END AMPLIFIERS

Placing one of the channel's DC/AC/GND switches to "GND" and the remaining switch to either "DC" or "AC" allows the oscilloscope to display the voltages applied to the active input.

## STORAGE CONTROL BUTTONS

The Storage Control consists of three buttons: LIVE, HOLD NEXT and HOLD LAST.

These buttons determine whether or not data stored in the display memory will be replaced when a valid trigger is received.

● LIVE

Pressing the LIVE button erases the displayed data from the screen, readying it for the next display.

It also serves as a "master reset," enabling the Plug-in to determine whether or not any of the controls have been altered since the last signal acquisition.

➤ IMPORTANT: Changes made to the Plug-in's controls, while the LIVE LED is illuminated, will NOT be acknowledged until either the operator presses the LIVE button or the next valid trigger occurs.

● HOLD NEXT

The Live mode must be activated before the HOLD NEXT button is pressed.

The stored data is replaced when the next valid trigger is received. The Plug-in enters the Hold mode as soon as the sweep is completed.

● HOLD LAST

Pressing the HOLD LAST button allows a sweep currently in progress to be completed and then inhibits any further sweeps.

Data stored in the display memory is protected when only the Hold Last LED is illuminated, (Hold mode).

NOTE: If data stored in portions of the memory is to be saved, ensure that the Live LED is off before repositioning the Mainframe's MEMORY switch. Otherwise, data will be replaced if a valid trigger is received.

●● Hold Mode

The Plug-in should be in the Hold mode (only the Hold Last LED is illuminated) whenever a Plug-in parameter is changed. See IMPORTANT note on Page 8-1.

● REMOTE CONTROL

Refer to Page 8-43, *Remote Control Connector* descriptions.

## ±VOLTS FULL SCALE SWITCH

Allows signals ranging from ±100 millivolts to ±40 volts full scale to be measured when the X1 probe is used.

A maximum of ±400 volts full scale can be measured when the optional X10 probe is used.

The voltage numerics are directly related to the measured voltages when either the X1 or special X10 probe is used. Refer to tab *Accessories* for information on the special X10 probe.

The screen can display up to 32,768 voltage levels when the VERTICAL EXPANSION switch is turned off.

If the zero volts reference is vertically centered on the screen, the positive voltages will be displayed above the zero volts level by up to 16,383 levels. The negative voltages will be displayed below the zero volts level by up to 16,384 levels. Refer to Figure 8-1.

Table 8-2 tabulates the voltage increment of each level (volts per level) according to the position selected on the ±VOLTS FULL SCALE switch.

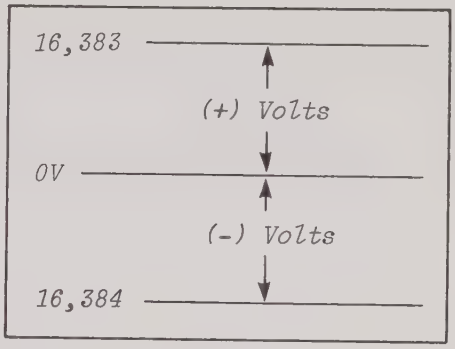



*Figure 8-1*

| ± V.F.S. | VOLTS PER LEVEL |
|---|---|
| 100 mV | *6.25 uV* |
| 200 mV | *12.50 uV* |
| 400 mV | *25.00 uV* |
| 1 V | *62.50 uV* |
| 2 V | *125.00 uV* |
| 4 V | *250.00 uV* |
| 10 V | *625.00 uV* |
| 20 V | *1.25 mV* |
| 40 V | *2.50 mV* |

*Table 8-2*

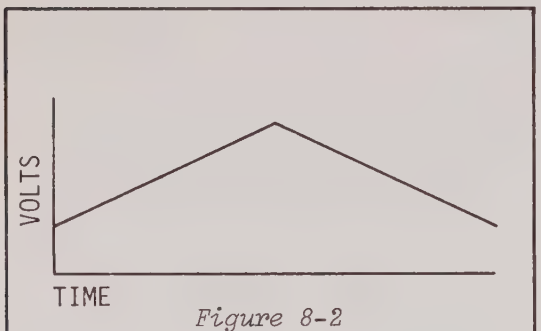



*Figure 8-2*

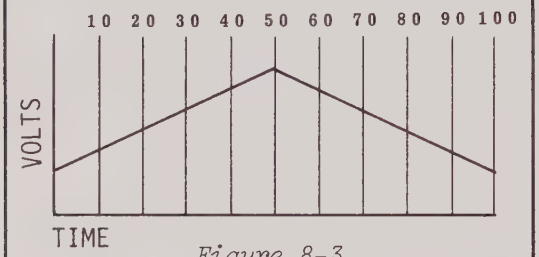



*Figure 8-3*

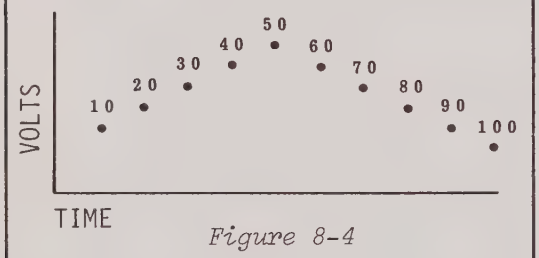



*Figure 8-4*

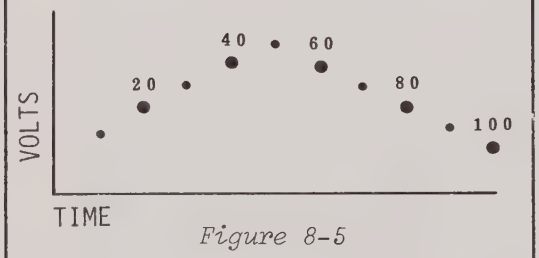



*Figure 8-5*

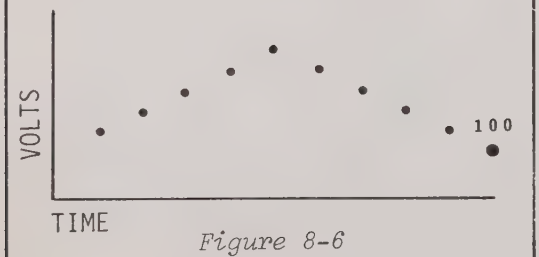



*Figure 8-6*

## TIME PER POINT SWITCH

Determines the time resolution of the displayed signal. The faster the time-per-point when the signal is acquired, the higher the time resolution.

The Plug-in samples and digitizes the input signal's voltages once every 10 microseconds. This sampling rate is preset within the oscilloscope's circuitry. However, which of the sampled voltages will be selected for display is determined by the TIME PER POINT switch.

*EXAMPLE #8-1*

*Figure 8-2: A typical input signal.*

*Figure 8-3: The 10 microsecond sampling rate superimposed over the signal.*

*Figure 8-4: The resulting digitized samples represented by dots.*

*Figure 8-5: Assume a time-per-point of 20 uSec. Every other digitized sample (larger dots) are selected for display.*

*Figure 8-6: Assume a time-per-point of 100 uSec's. Every tenth digitized sample (large dot) is selected for display.*

The number of allotted addresses (words) with which the display memory will record each input signal depends upon -

#1. The positions of the CHANNEL A and B "ON/OFF" switches; and

#2. The position selected on the Mainframe's MEMORY switch

Table 8-3 tabulates the approximate number of memory addresses that will record each input signal.

| CHANNEL SWITCH | | MEMORY SWITCH POSITION | | |
|---|---|---|---|---|
| A | B | ALL | HALVES | QUARTERS |
| ON | OFF | *16K* | *8K* | *4K* |
| OFF | ON | *16K* | *8K* | *4K* |
| ON | ON | *8K* | *4K* | *2K* |

*Table 8-3*

NOTE: Table 8-3 is for single Plug-in operation only.

## SWEEP TIMES

Table 8-4 tabulates the approximate sweep times for single-channel measurements. For multiple channels, divide the listed times accordingly:

Two channels ---------- (2)
Three or four channels --------- (4)

| TIME PER POINT SWITCH | MEMORY SWITCH POSITIONS (Data Points Per Sweep) | | |
|---|---|---|---|
| | ALL (15,872) | H1/H2 (7,936) | Q1/Q2/Q3/Q4 (3,968) |
| | *Milliseconds Per Sweep* | | |
| 10 µS | 158.800 | 79.400 | 39.700 |
| 20 | 317.600 | 158.800 | 79.400 |
| 50 | 794.000 | 397.000 | 198.500 |
| 100 | 1588.000 | 794.000 | 397.000 |
| 200 | | 1588.000 | 794.000 |
| | *Minutes Per Sweep* | | |
| 1 mS | 0.264 | 0.132 | 0.066 |
| 2 | 0.528 | 0.264 | 0.132 |
| 5 | 1.320 | 0.660 | 0.330 |
| 10 | 2.640 | 1.320 | 0.660 |
| 20 | 5.280 | 2.640 | 1.320 |
| 50 | 13.200 | 6.600 | 3.300 |
| | *Hours Per Sweep* | | |
| 0.1 S | 0.440 | 0.220 | 0.110 |
| 0.2 | 0.880 | 0.440 | 0.220 |
| 0.5 | 2.200 | 1.100 | 0.550 |
| 1 | 4.400 | 2.200 | 1.100 |
| 2 | 8.800 | 4.400 | 2.200 |
| 5 | 22.000 | 11.000 | 5.500 |
| 10 | 44.000 | 22.000 | 11.000 |
| 20 | 88.000 | 44.000 | 22.000 |
| 50 | 220.000 | 110.000 | 55.000 |
| 100 | 440.000 | 220.000 | 110.000 |
| 200 | 880.000 | 440.000 | 220.000 |

*Table 8-4*

● EXT I & II POSITIONS

The EXT I (fast) and EXT II (slow) time-per-point positions are used when -

#1. The desired time-per-point is not available on the TIME PER POINT switch; or

#2. The sampling rate is generated from a nonlinear time base.

The number of allotted addresses (words) that will record each input signal depends upon -

#1. The positions selected on the CHANNEL A and B "ON/OFF" switches; and

#2. The position selected on the Mainframe's MEMORY switch.

Table 8-5 tabulates the corresponding number of memory addresses that will record each input signal.

NOTE: Table 8-5 is for single Plug-in operation only.

The sampling of the input signal will begin *** nS to *** nS (and end *** nS to *** nS) after the "EP" command is applied to the Remote Control Connector.

| CHANNEL SWITCH | | MEMORY SWITCH POSITION | | |
|---|---|---|---|---|
| A | B | ALL | HALVES | QUARTERS |
| ON | OFF | *15,872* | *7,936* | *3,968* |
| OFF | ON | *15,872* | *7,936* | *3,968* |
| ON | ON | *7,936* | *3,968* | *1,984* |

*Table 8-5*

IN EXT I (fast) mode, a delay will occur between the time of the first sample and the time at which a display will appear. This delay occurs because the samples are stored by the Plug-in's buffer memory before being "dumped" into the display memory.

This time delay can be approximated by multiplying the allotted addresses (from Table 8-5) by the average time period between each sample. See Equation 8-1.

Time Delay = (addresses) x (period)

*Equation 8-1*

In EXT II (slow) mode, each sample will be displayed as soon as it is acquired, allowing real-time monitoring of slow signals.

● EXT I Position

The EXT I position is used when the sampling rate is between *** µS and ** µS (or *** µS and *** µS if averaging is applied). The EXT I mode requires two external commands to acquire samples:

#1. A valid trigger command; and
#2. A TTL input signal (EP command) applied to the Remote Control Connector.

The trigger command initiates the sampling sequence and first data point acquisition, and the "EP" commands determine the sampling rate. Samples are acquired with *** nS of the leading, positive edge of the "EP" commands. The buffer memory stores all of the data points before "dumping" them into the display memory.

NOTE: The Point Average mode is not operable in the EXT I mode.

*EXAMPLE #8-2*

*Figure 8-7: Typical input signal.*

*Figure 8-8: "EP" commands superimposed over the input signal.*

*Figure 8-9: A valid trigger occurring at that point in time.*

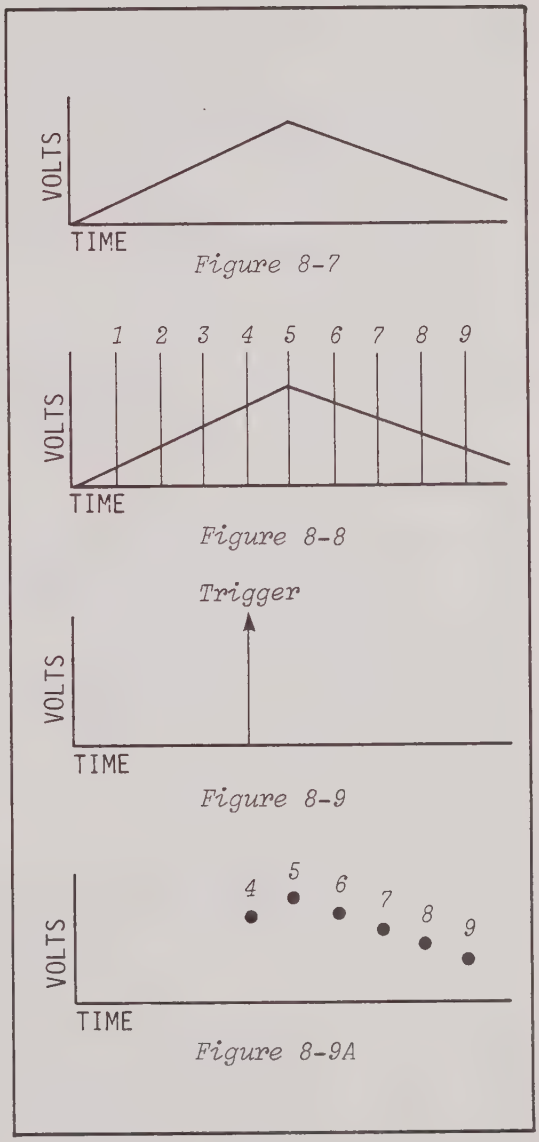



*Figure 8-9A: The corresponding digitized samples, represented by the dots, that will be stored in the display memory.*

** Exact spec's to be verified.*

● EXT II POSITION

The EXT II position is used when the sampling rate is equal to, or slower than ** µS (or *** µS if averaging is applied). The EXT II mode requires two external commands to acquire samples:

#1. A valid trigger command; and
#2. A TTL input signal (EP command) applied to the Remote Control Connector.

The trigger command initiates the sampling sequence and the first data point acquisition, and the "EP" commands determine the sampling rate. Each data point will immediately appear on the display screen as each one is acquired.

NOTE: The Point Average mode is not operable in the EXT II mode.

*EXAMPLE #8-3*

*Figure 8-10: Typical input signal.*

*Figure 8-11: "EP" commands superimposed over the input signal.*

*Figure 8-12: A valid trigger occurring at that point in time.*

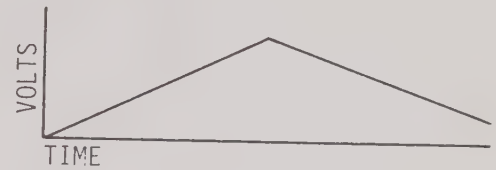



*Figure 8-10*

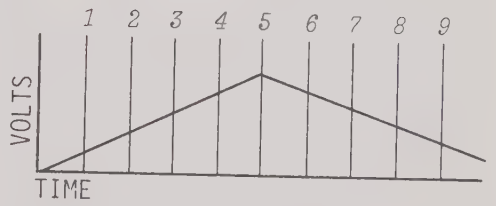



*Figure 8-11*

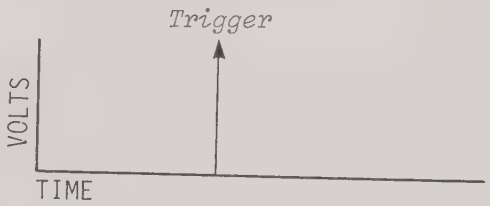



*Figure 8-12*

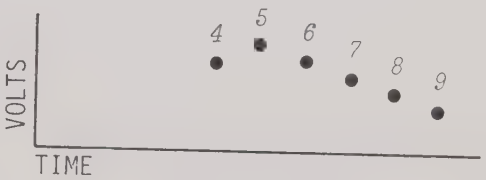



*Figure 8-13*

*Figure 8-13: The corresponding digitized samples, represented by the dots, that will be stored in the display memory.*

## FILTER SWITCH

Rejects high frequency "noise" components on the input signal.

This feature can be used in any acquisition mode, including Average and Point Average.

NOTE: 1 kHz = -*db/point.

## POSITION CONTROL

Vertically repositions a "live" display on the screen.

NOTE: The POSITION control does not introduce a dc offset to the signal. Rather, it varies the location of the zero volts reference on the screen by up to 60% of the selected Volts Full Scale.

For example, if the selected Volts Full Scale equals ±1V, the display can be varied from (+1.6 V to -0.4 V) down to (-1.6 V to +0.4 V) by using the POSITION control.

The voltage numerics will remain unchanged when the POSITION control is used.



* *Exact spec's to be verified.*

## SAVE REFERENCE SWITCH

► IMPORTANT: The Trigger View mode overrides the Save Reference mode. See IMPORTANT note on Page 8-30.

Allows "live" and stored signals to be compared when the Plug-in is operating in the Live mode. This enables the operator to observe the effects of altering the characteristics of the input signal.

Turning the SAVE REFERENCE switch on causes alternate, displayed data point coordintes to become "frozen" in the display memory's addresses. The remaining addresses continue to record changes in the input signal and display these changes superimposed over the "frozen" data points. The reference of the "frozen" display is protected in the Live mode.

In addition, the Plug-in/Channel numerics will also display a letter "R" suffix indicating which data points have been saved ("frozen").

The display returns to normal operation when the switch is turned off.

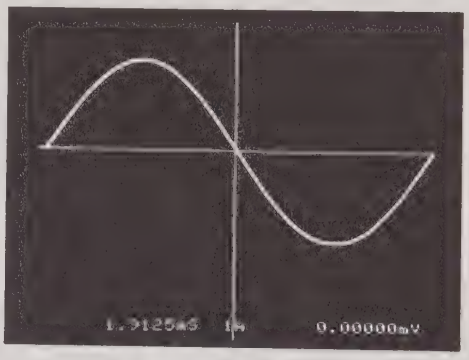



*Figure 8-14*

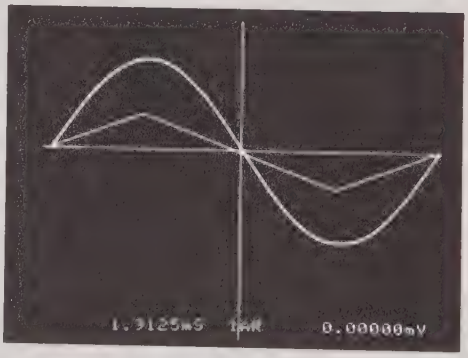



*Figure 8-15*

*EXAMPLE #8-4*

*Figure 8-14: Typical signal acquired with SAVE REFERENCE turned off.*

*Figure 8-15: Resulting display of the altered signal superposed over the original signal when the SAVE REFERENCE switch was turned on.*

## AVERAGE SWITCH

Reduces the effects of "noise" on recurrent input signals by "sweep" averaging successive sweeps.

To function properly, the input signal must be time-locked to an associated trigger signal.

The sampling rate is determined by the selected Time-Per-Point.

Sample voltages acquired during the first sweep are stored in the memory. Then, samples acquired during the second sweep are averaged with those acquired during the first sweep. Each "newer" average, computed from Equation 8-2, updates the memory.

This process of averaging "new" samples with the "old" averages stored in the memory repeats for each sweep.

$$SV_{ave} = Old \times \frac{(K-1)}{K} + \frac{New}{K}$$

*Equation 8-2*

- (Old): The average voltage value currently stored in the memory's address.
- (New): The newest sampled voltage acquired during the current sweep.
- (K): The values tabulated in Table 8-6, corresponding to the sweep in progress.

| SWEEP | 1 | 2 | 3-5 | 6-10 | 11-21 |
|---|---|---|---|---|---|
| K | *1* | *2* | *4* | *8* | *16* |

*Table 8-6*

The term "K" is computed from Equation 8-3. The result is rounded off to the nearest, lower power of two, $(2^n)$.

$$K = Sweep + \frac{Sweep}{2}$$

*Equation 8-3*

NOTE: This type of averaging is called virtual averaging and is similar to "true" or normalized averaging. However, unlike normalized averaging, virtual averaging "weights" each sweep differently because of the use of binary number "K" instead of "N" (Number of Sweeps). If the variations in voltages, from sweep to sweep, are due entirely to "noise" and not because of signal changes, the result is identical.

*EXAMPLE #8-5*

*Figure 8-16: First sweep sampled at 1V1, 1V2, .... $1V_x$.*

*Figure 8-17: Second sweep sampled at 2V1, 2V2, .... $2V_x$.*

*Figure 8-18: Third sweep sampled at 3V1, 3V2, .... $3V_x$.*

*If -*
*1V1 = 8V, 2V1 = 10V, and 3V1 = 8V, the average value of the first data point displayed ($AV_1$, $AV_2$, $AV_3$) during each of the three sweeps equals:*

$$AV_1 = 0V \times \frac{(1-1)}{1} + \frac{8V}{1} = 8V$$

$$AV_2 = 8V \times \frac{(2-1)}{2} + \frac{10V}{2} = 9V$$

$$AV_3 = 9V \times \frac{(4-1)}{4} + \frac{8V}{4} = 8.75V$$

*Figure 8-19: The upper display illustrates a "noisy" signal acquired without the Average mode.*

*The lower display illustrates, after several sweeps, the same "noisy" signal captured with the Average mode.*

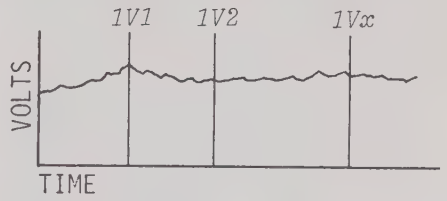



*Figure 8-16*

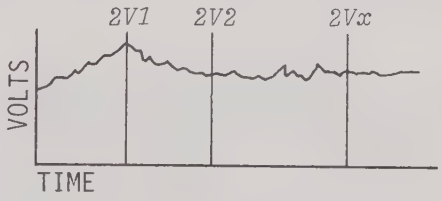



*Figure 8-17*

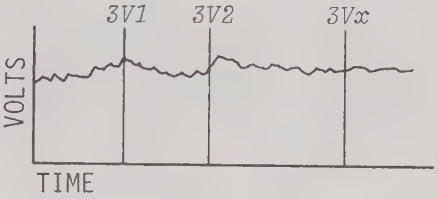



*Figure 8-18*

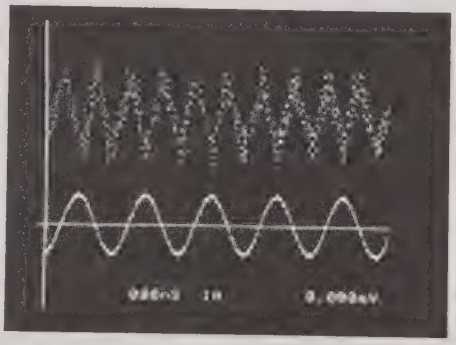


*Figure 8-19*

## POINT AVERAGE SWITCH

Reduces the effects of "noise" on an input signal acquired when the time-per-point is slower than *** micro-seconds.

The oscilloscope acquires data at a constant rate of *** microseconds per sample. As each sample is acquired, it is averaged with the preceding samples within the same sampling period (time-per-point setting).

For example, an average is computed from the values of the first and second samples which, in turn, is averaged with the value of the third sample, etc.

When the last sample within the string has been averaged, the final averaged value is stored in one of the memory's addresses and displayed by a single data point coordinate.

This process repeats until each one of the memory's allotted addresses has recorded an average value.

The point average values are computed by Equation 8-4.

$$PV_{ave} = Old \times \frac{(K-1)}{K} + \frac{New}{K}$$

*Equation 8-4*

- (Old): The average voltage value currently stored in the memory's address.
- (New): The newest sampled voltage acquired within the string.
- (K): The values tabulated in Table 8-7, corresponding to the sample being acquired.

| SAMPLE | 1 | 2 | 3-5 | 6-10 | 11-21 |
|---|---|---|---|---|---|
| K | *1* | *2* | *4* | *8* | *16* |

*Table 8-7*

The term "K" is computed from Equation 8-5. The result is rounded off to the nearest, lower power of two, $(2^n)$.

$$K = Sample + \frac{Sample}{2}$$

*Equation 8-5*

**Exact spec's to be verified.*

*EXAMPLE #8-6*

*Assume that a string of three samples will be point averaged for each data point coordinate.*

*Figure 8-20: The first string sampled at 1V1, 1V2, and 1V3 for the first data point to be displayed in the sweep. (Sample 2V1 starts the second string of samples for the second data point.)*

*If-*
*1V1 = 6V, 1V2 = 8V, and 1V3 = 4V, the average voltage value of the first data point to be displayed in the sweep will equal 6.25 volts.*

*Where -*

$$PV_1 = 0V \times \frac{(1-1)}{1} + \frac{6V}{1} = 6V$$

$$PV_2 = 6V \times \frac{(2-1)}{2} + \frac{8V}{2} = 7V$$

$$PV_3 = 7V \times \frac{(4-1)}{4} + \frac{4V}{4} = 6.25V$$

*Figure 8-21: The upper display illustrates a "noisy" signal acquired without the Point Average mode.*

*The lower display illustrates, after one sweep, the same "noisy" signal captured with the Point Average mode.*

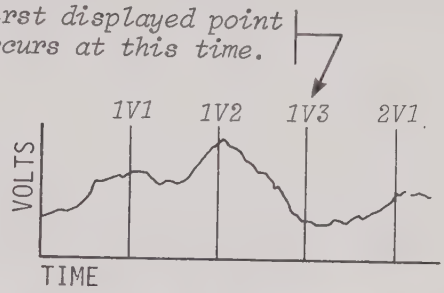



*Figure 8-20*

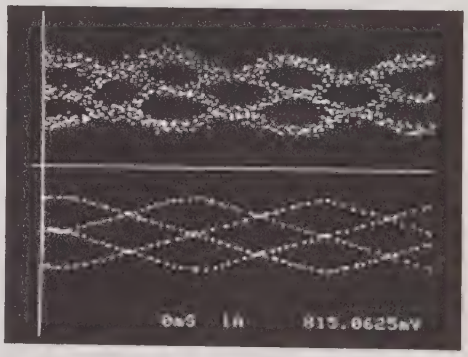


*Figure 8-21*

● COMBINING AVERAGE & POINT AVERAGE

The "sweep" Average and Point Average modes of operation can be combined if the time-per-point is slower than *** microseconds. The effectiveness of averaging very "noisy," repetitive signals is enhanced when both of these modes are combined.

Essentially, Point Averaged values acquired during the first sweep are recorded in the memory's addresses. Then, as each "new" Point Averaged value is acquired in the second sweep, it is "sweep" Averaged with the corresponding value stored in the memory. The resulting average values continually replace the "older" values stored in the memory.

This process of "sweep" Averaging the "older" values stored in the memory with the "newer" Point Averaged values acquired during the current sweep repeats with every sweep, providing additional improvements in the signal to noise ratio.

The FILTER switch can also be used in conjunction with the Average and/or Point Average modes of operation.

*Exact spec's to be verified.*

## SOURCE SWITCH

Selects whether the triggers will be derived from either the channel A or channel B amplifiers, or through the EXT input BNC.

- EXT

Selected when the trigger is applied to the EXT input BNC, enabling a common trigger to simultaneously initiate sweeps on both channels.

The amplitude of the signal must be *** volts minimum to qualify as a valid trigger.

- A or B

Selected to allow amplification of the signal before it enters the trigger detection circuits. The signal must be at least **% of the selected Volts Full Scale to qualify as a valid trigger.

NOTE: A valid trigger applied to channel A will also initiate a sweep on channel B if the CHANNEL B "ON/OFF" switch is turned on. The opposite is true when a trigger is applied to CHANNEL B.

- S

Selected when multiple Plug-ins will be triggered by a common signal.

The trigger must be applied to the "Master" Plug-in and the position selected on that Plug-in's SOURCE switch (A, B, or EXT) must correspond accordingly.

The remaining Plug-in(s) are referred to as the Slave Plug-ins. The SOURCE switch(es) must be placed to the "S" position.

A trigger applied to the Master Plug-in will also trigger a sweep at the Slave Plug-ins.

## AUTO/NORM SWITCH

Determines whether the trigger will be generated internally in the absence of a valid trigger signal or solely by an external source.

- AUTO

Automatically triggers in the absence of a valid trigger.

- NORM

The trigger is externally generated. The next valid trigger to occur, after the preceding sweep has been completed, will initiate a new sweep.

## COUPLING SWITCH

Determines whether or not a dc component on the triggering signal being applied to the EXT input BNC will be attenuated.

- AC

Signals are capacitively coupled to the trigger detection circuit. DC components of approximately 2 hertz, or less, are attenuated while the ac component is allowed to pass.

- DC

Both ac and dc components of the signal are coupled to the trigger detection circuitry.

## VIEW SWITCH

►IMPORTANT: Displayed data will be erased from the display memory when the VIEW switch is turned on. Precautions must be taken if the displayed data is to be saved. (Such as recording the data on a diskette or placing the MEMORY switch to an empty, or unimportant, "halves" or "quarters" position.) In addition, the View mode will override the Save Reference mode and the functions of the TRIG POSITION controls.

Two horizontal lines appear and the Plug-in's Trigger cursor moves to screen center when VIEW is selected and the Plug-in is operating in the Live mode with sweeps occurring. A letter "V" suffix will be added to the Plug-in/Channel numerics, (e.g., 1AV). If external triggering is selected, the Plug-in number will be followed by an "EV" suffix, (e.g., 1EV).

The configuration and position of the two lines indicate the slope (page 8-31), minimum amplitude (page 8-32), and minimum voltage change (page 8-33) that the signal must experience to qualify as a valid trigger. All three characteristics must be met by the signal before a sweep will be initiated.

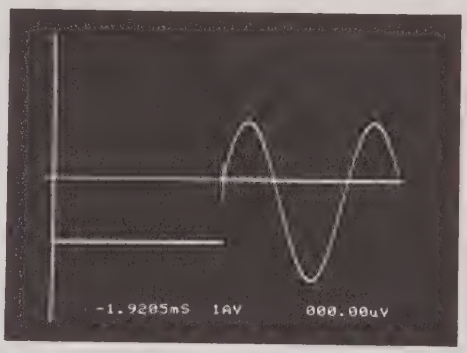



*Figure 8-22*

To use the VIEW mode:

#1. Take precautions to save any important data stored in the display memory.

#2. If any of the Plug-in's controls must be repositioned, place the Plug-in into the Hold mode, or press the LIVE button after the controls have been repositioned.

#3. AUTO/NORM switch: As required.

#4. VIEW switch: On

#5. LIVE button: Press.

*EXAMPLE #8-7*

*Figure 8-22: Typical VIEW display with Positive Slope selected.*

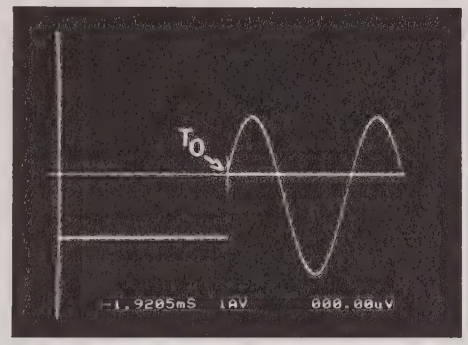



*Figure 8-23*

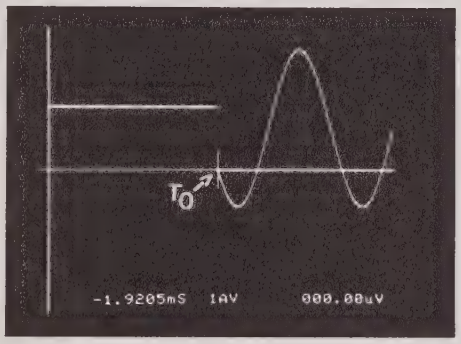



*Figure 8-24*

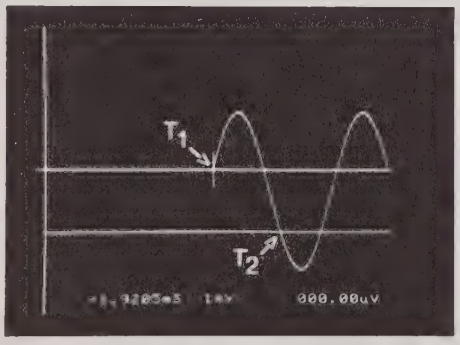



*Figure 8-25*

## SLOPE SWITCH

►NOTE: See IMPORTANT note on page 8-30 before turning on VIEW switch.

Determines whether positive and/or negative going voltage transitions will qualify the signal as a trigger.

● (+) Slope
The signal voltage must be increasing.

● (-) Slope
The signal voltage must be decreasing.

● DUAL Slope
Either increasing or decreasing voltage values will qualify the signal.

*EXAMPLE #8-8*

*Figure 8-23: (+) slope display. Signal qualifies as a valid trigger component at point ($T_0$).*

*Figure 8-24: (-) slope display. Signal qualifies as a valid trigger component at point ($T_0$).*

*Figure 8-25: DUAL slope display. Signal qualifies as a valid trigger at either point ($T_1$) or ($T_2$).*

## LEVEL CONTROL

►NOTE: See IMPORTANT note on page 8-30 before turning on VIEW switch.

The LEVEL control adjusts the threshold levels which, when crossed by the signal, will qualify the signal as a valid trigger component.

Which of the two lines must be crossed by the signal is a function of the SLOPE switch.

- (+) - The signal must cross the upper threshold level.
- (-) - The signal must cross the lower threshold level.
- DUAL - The signal can cross either threshold level.

*EXAMPLE #8-9*

*Figure 8-26: A (+) slope display. Signal qualifies as a valid trigger component at point ($T_0$).*

*Figure 8-27: A (-) slope display. Signal qualifies as a valid trigger component at point ($T_0$).*

*Figure 8-28: A DUAL slope display. Signal qualifies as a valid trigger at either point ($T_1$) or ($T_2$).*

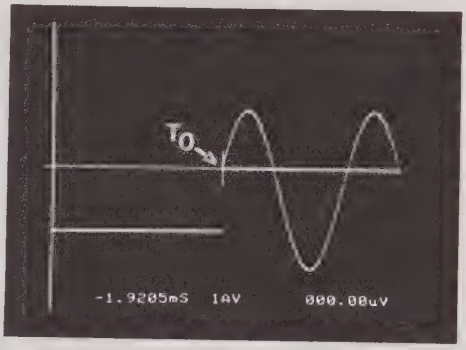



*Figure 8-26*

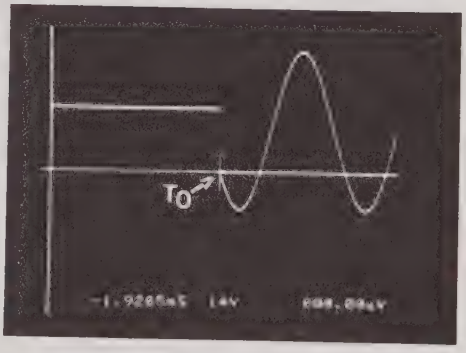



*Figure 8-27*

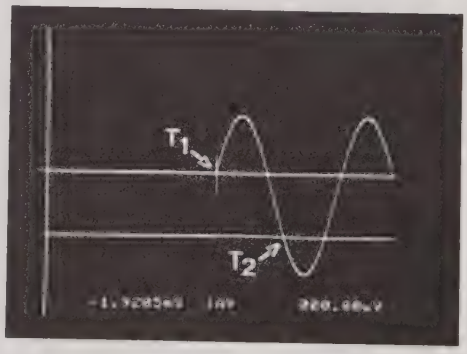



*Figure 8-28*

## SENSITIVITY CONTROL

►NOTE: See IMPORTANT note on page 8-30 before turning on VIEW switch.

Adjusts the distance (window) between the two threshold levels. This "window" must be crossed by the signal in order to qualify as a valid trigger component when either (+) or (-) slope triggering is selected.

The "window" voltage can be adjusted from a range of *** millivolts to ** volts when triggering via the EXT input BNC. And from *% to **% of the Volts Full Scale when triggering via the channel A or B amplifiers.

The voltage numerics will alternate between the voltage values of the upper and lower threshold levels when the vertical cursor is moved across the display screen with Autocenter turned on.

*EXAMPLE #8-10*

*Figure 8-29: "Window" voltage (Vab) equals the difference between the upper limit (Va) and lower limit (Vb) voltage values.*

*Figure 8-30: The dashed lines on the second positive-going slope indicates an amplitude of sufficient size to qualify the signal as a valid trigger component.*

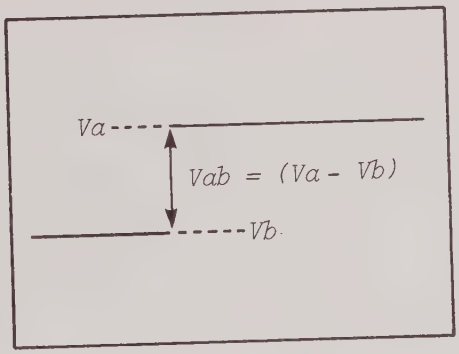



*Figure 8-29*

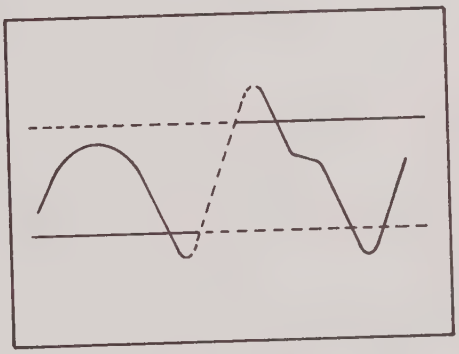


*Figure 8-30*

*Exact spec's to be verified.

## RECURRENT TRIGGERING

### ● (+) or (-) SLOPE TRIGGERING

After the first trigger has been initiated, the signal's slope must reverse, pass through the "window," reverse again, and then pass through the "window" once more in order to initiate another trigger.

*EXAMPLE #8-11*

*Assume (+) Slope triggering has been selected and the VIEW switch is on.*

*Figure 8-31: The first positive slope (solid line) starts below the lower threshold level, passes through the "window," and initiates a trigger at point ($T_1$). The dashed lines represent the path that the signal must follow in order to initiate a second trigger at point ($T_2$).*

*Figure 8-32: Once again, the signal qualifies as a trigger at point ($T_1$). Since the second positive slope did not start below the lower threshold, a trigger will not occur at point (A). It will, however, occur at point ($T_2$) because the positive slope begins below the lower threshold.*

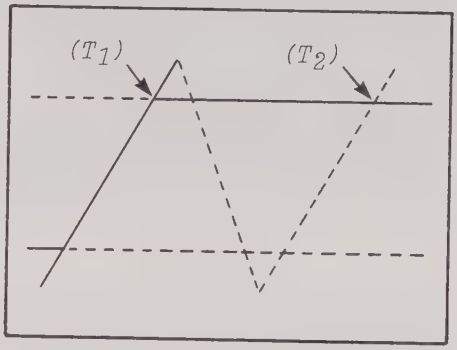



*Figure 8-31*

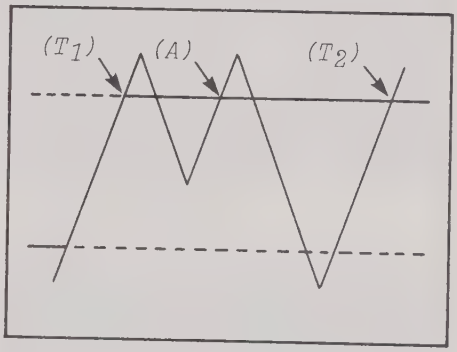



*Figure 8-32*

● DUAL SLOPE TRIGGERING

Recurrent triggers will be initiated each time the signal crosses either threshold level with the proper slope. The signal does not have to recross through the "window."

NOTE: The signal must experience a voltage change of *% (minimum) of the selected Volts Full Scale to qualify as a valid trigger.

*EXAMPLE #8-12*

*Assume "DUAL" slope triggering has been selected on the SLOPE switch and the VIEW switch is on.*

*Figure 8-33: Valid triggers will occur at points ($T_1$ thru $T_4$) because the signal crosses the threshold levels with the correct slopes.*

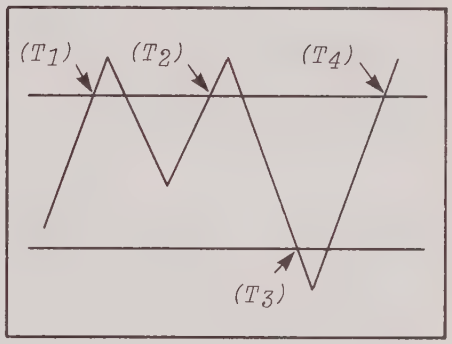



*Figure 8-33*

** Exact spec's to be verified.*

## ADJUSTING THE TRIGGER

- (+) or (-) SLOPE TRIGGERING

#1. SLOPE: (+) or (-)

#2. AUTO/NORM: Auto

#3. COUPLING: As required.

#4. VIEW: On

#5. Trigger: Apply to EXT input BNC or to one of the channels.

#6. SOURCE: As required.

#7. DC/AC/GND: As required.

#8. LIVE: Press.

#9. POSITION: Adjust display for best placement.

#10. VOLTS FULL SCALE: As required.

#11. SENSITIVITY: Full counterclockwise. Then adjust clockwise until the "window" exceeds any "noise" spikes.

#12. LEVEL: Adjust until the upper threshold (+ slope) or lower threshold (- slope) intersects the desired trigger point.

#13. Fine tune the SENSITIVITY and LEVEL controls as required.

#14. After the SENSITIVITY and LEVEL controls have been properly positioned, place the AUTO/NORM switch to the "NORM" position. The Plug-in will continue to trigger.

NOTE: The TRIGGER light illuminates when a valid trigger is received and remains illuminated until the sweep is completed.

- DUAL SLOPE TRIGGERING

#1. SLOPE: Dual

#2. AUTO/NORM: Auto

#3. COUPLING: As required.

#4. VIEW: On

#5. Trigger: Apply to EXT input BNC or to one of the channels.

#6. SOURCE: As required.

#7. DC/AC/GND: As required.

#8. LIVE: Press.

#9. POSITION: Adjust display for best placement on screen.

#10. VOLTS FULL SCALE: As required.

#11. SENSITIVITY: Full counter-clockwise.

#12. LEVEL: Adjust until "window" is centered between the desired positive and negative trigger points.

#13. SENSITIVITY: Adjust until the upper and lower threshold levels intersect the desired positive and negative trigger points.

#14. Fine tune the LEVEL and SENSITIVITY controls as required.

#15. After the SENSITIVITY and LEVEL controls have been properly positioned, place the AUTO/NORM switch to the "NORM" position. The Plug-in will continue to trigger.

NOTE: The TRIGGER light illuminates when a valid trigger is received and remains illuminated until the sweep is completed.

## TRIGGER POSITION CONTROLS

The TRIG POSITION controls consist of a ZERO button (common to both channels), paddle "A" (channel A only), and paddle "B" (channel B only).

These controls select whether post-trigger (Normal), pre- and post-trigger (Cursor), or delayed trigger (Delayed) events will be displayed.

NOTE: These can be mixed or matched in multiple channel operation. Refer to *Special Procedures* tab, page 15-5.

● LIVE MODE (Coarse Adjust)
Pressing the paddle control causes the Trigger cursor to move 1/8 of full screen at the end of each sweep.

● LIVE MODE (High Speed Adjust)
Pressing, and holding, the LIVE button and paddle control causes a high speed movement of the Trigger cursor.

● SET-UP MODE (Fine Adjust)
Initiated by simultaneously pressing the HOLD LAST and HOLD NEXT buttons, illuminating all three STORAGE control LEDs. NOTE: ENSURE THAT THE HOLD LAST BUTTON IS RELEASED FIRST. The trigger's rate of movement increases the longer the paddle is pressed. Releasing and then repressing the paddle returns the advance to a slower rate of movement. The letter "S" suffix is added to the Plug-in/Channel numerics, (i.e., 1AS), when the Set-up mode is selected.

►IMPORTANT: OPERATING THE PADDLE CONTROLS, OR ZERO BUTTON, IN THE "SET-UP" MODE ALTERS THE ($T_0$) ORIGIN, CAUSING THE TIME NUMERICS TO BECOME ERRONEOUS. The "set-up" mode can be exited by pressing either the HOLD LAST or LIVE button. However, the time numerics will remain erroneous until a new sweep is acquired.

*EXAMPLE #8-13*

*Figure 8-34: The types of triggers and related sweeps during which data is acquired for display.*

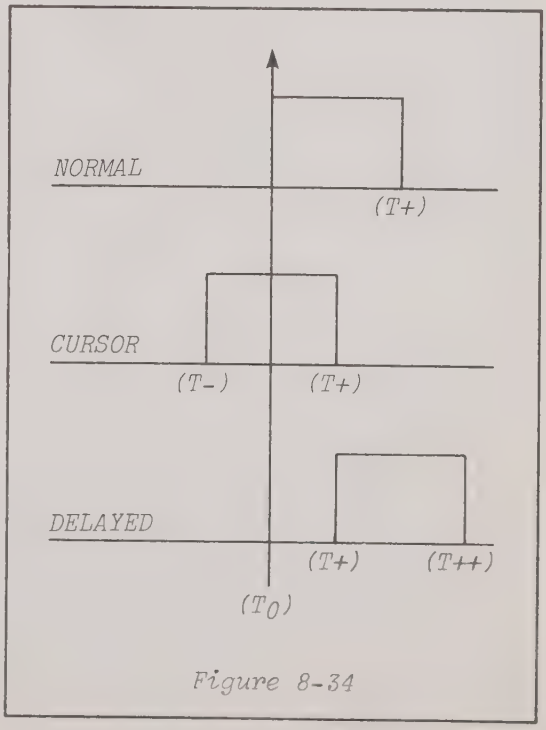



*Figure 8-34*

● NORMAL TRIGGER DISPLAY

The oscilloscope immediately resets to the Normal Trigger mode when the ZERO button is pressed and the Plug-in is operating in the "set-up" mode. If the Plug-in is operating in the LIVE mode, valid triggers must be occurring while the ZERO button is pressed, since the "reset" command will not be recognized until the end of the sweep.

If the Plug-in is operating in the LIVE mode and -

#1. a long sweep is in progress, or

#2. no triggers are occurring, or

#3. a long delay has been selected,

then, to quickly reset the delay to zero, hold the ZERO button in and momentarily press the LIVE button.

The Plug-in's Trigger cursor is positioned at the extreme left-hand side of the screen when the oscilloscope is operating in the Normal Trigger mode. Only those events occurring after a valid trigger will be displayed on the screen.

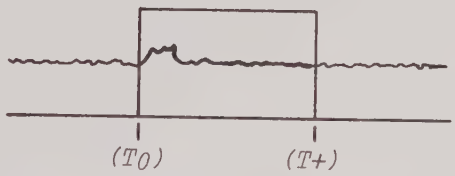



*Figure 8-35*

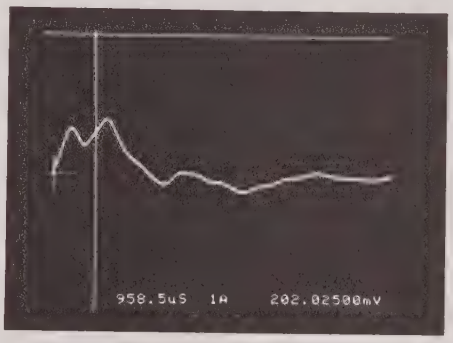



*Figure 8-36*

*EXAMPLE #8-14*

*Figure 8-35: A typical input signal.*

*The boxed area represents one complete sweep starting at point ($T_0$), the trigger, and ending at point (T+).*

*Figure 8-36: The corresponding Normal Trigger display of the signal captured during the sweep.*

● CURSOR TRIGGER DISPLAY

The oscilloscope enters the Cursor Trigger mode when the TRIG POSITION paddle is pressed to the right and the Plug-in is operating in the "set-up" mode. If the Plug-in is operating in the LIVE mode, valid triggers must be occurring while the ZERO button is pressed.

NOTE: If the Plug-in is in the LIVE mode and a long sweep is in progress, the Cursor Trigger command may not be acknowledged until the next sweep is initiated. (The TRIG POSITION paddle must be pressed towards the right as the new sweep is initiated.)

The Plug-in's Trigger cursor will reposition towards the right-hand side of the screen, stopping when the paddle is released. Pre-trigger events will be displayed to the left of the trigger cursor. Post-trigger events will be displayed to the right of it.

Essentially, data is continually being sampled and stored in the memory. When a valid trigger is received, the pre-trigger events are stored in the memory and the post-trigger events fill the remaining memory addresses.

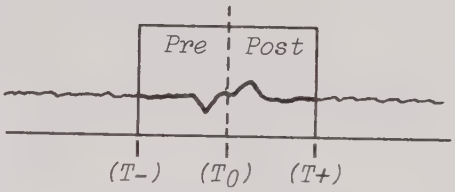



*Figure 8-37*

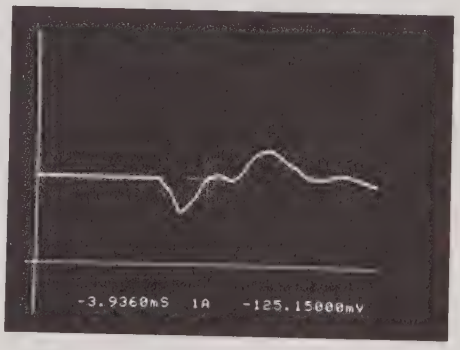



*Figure 8-38*

*EXAMPLE #8-15*

*Figure 8-37: A typical input signal. The boxed area represents one complete sweep starting at point (T-) and ending at point (T+). Point ($T_0$), the trigger, "locks" the pre-trigger data in the memory's addresses. The remaining addresses will record the post-trigger data.*

*Figure 8-38: The corresponding display of the captured input signal.*

● DELAYED TRIGGER DISPLAY

NOTE: Reposition the Mainframe's vertical cursor to the extreme left-hand side of the screen before activating the Delayed Trigger mode.

The oscilloscope enters the Delayed Trigger mode when the TRIG POSITION paddle is pressed to the left and the Plug-in is operating in the "set-up" mode. If the Plug-in is operating in the LIVE mode, valid triggers must be occurring while the ZERO button is pressed.

NOTE: If the Plug-in is in the LIVE mode and a long sweep is in progress, the Delayed Trigger command may not be acknowledged until the next sweep is initiated. (The TRIG POSITION paddle must be pressed towards the left when the new sweep is initiated.)

The Plug-in's Trigger cursor (time zero) repositions to the left and continues to reposition off the left of screen. The time delay, indicated by the time numerics, reflects the time difference between the "positions" of the Trigger cursor and vertical cursor.

Equation 8-6 computes the maximum time delay ($T_{max}$) that can be selected.

$$T_{max} \approx \frac{2^{24} \times (TPP)}{(Channels) \times (Memory)}$$

*Equation 8-6*

- (TPP): Time-per-point selection.
- (Channels): The number of channels turned on.
- (Memory): The position selected on the MEMORY switch: "ALL" = 1, "Halves" = 2, and "Quarters" = 4.

The Mainframe's vertical cursor can be repositioned after the delay has been set to inspect specific data point coordinates.

NOTE: Sometimes a very long delay may be inadvertently selected in the Delayed Trigger mode of operation. To quickly clear the delay, hold the ZERO button in and momentarily press the LIVE button.

*EXAMPLE #8-16*

*Figure 8-39: A typical input signal applied to an input BNC.*

*Point ($T_0$) indicates the point at which a valid trigger initiated the time delay.*

*The boxed area represents one complete sweep, starting at Point (T+) which represents the end of the time delay. Point (T++) represents the end of the sweep, during which time data was acquired for display.*

*Figure 8-40: The corresponding Delayed trigger display of the signal captured during the sweep.*

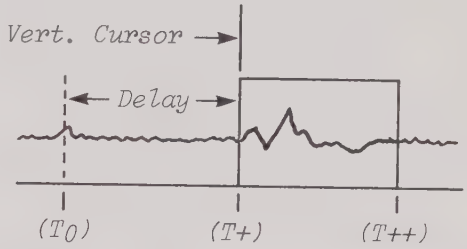



*Figure 8-39*

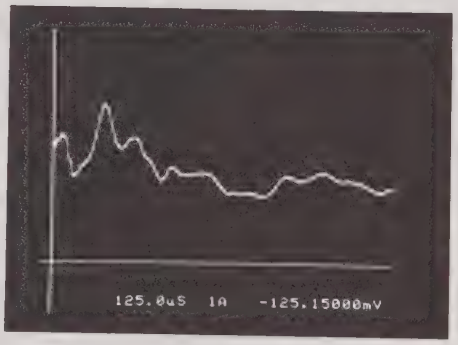



*Figure 8-40*

## REMOTE CONTROL CONNECTOR

Events can occur so rapidly that the operator's reaction time is not fast enough to capture them.

This problem can be resolved by simulating certain commands with external sensors possessing the required reaction times.

Figure 8-41 identifies the function of each pin.

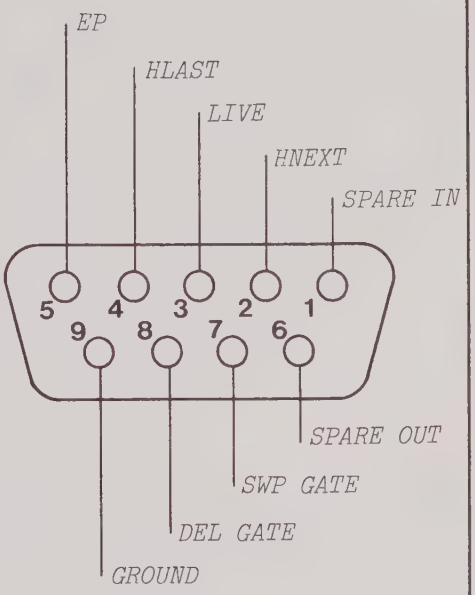



*Figure 8-41*

- HOLD LAST, LIVE and HOLD NEXT

The Storage Control buttons can be simulated by shorting the corresponding pins to ground through a low resistance contact or with an open collector TTL gate.

NOTE: Use the ground provided by Pin 9 on the Remote Control Connector.

- EP

The EP input is used to advance the memory to its next address when the TIME PER POINT switch is in either the EXT I or II positions.

The EP input should normally rest at less than 0.4 volts and then be raised to more than 3 volts DC each time the memory is to advance one address.
The "EP" input is TTL compatible.

● DEL GATE

The Delayed Gate output activates when either channel receives a valid trigger.

The output normally rests at 0.4 volts and rises to +3 VDC immediately following the valid trigger. It will return to 0.4 volts as soon as the sweep has been completed.

Figure 8-42 illustrates the three types of triggers and corresponding sweeps and Delayed Gate outputs.

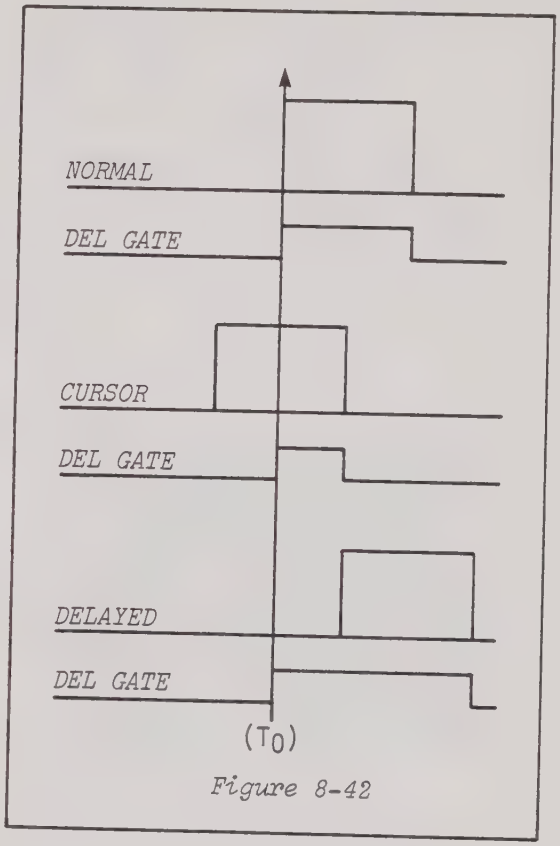



*Figure 8-42*

● SWP GATE

The Sweep Gate output is activated only during valid data point collection.

The output normally rests at 0.4 volts and rises to +3 VDC when a sweep is in progress.

● SPARE IN/SPARE OUT

Not currently being used.

## PROBE POWER CONNECTOR

A ±12 VDC output voltage, with a maximum current of *** ma, is available from the Probe Power connector.

The voltage polarities and ground are identified in Figure 8-43.

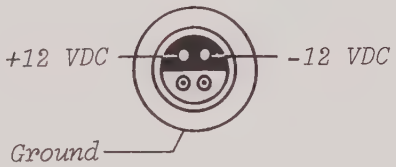



*Figure 8-43*

## COMPENSATION POINT

Touching the test probe to the COMP point produces a square-wave on the screen.

►IMPORTANT: The Time Per Point must be 20 µSeconds or faster.

Compensate the test probe for the best response time (rise and fall times) on the square-wave display.

*EXAMPLE #8-17*

*Figure 8-44 illustrates a square-wave displayed with expansion applied.*

*The top square-wave was produced from an uncompensated probe. The bottom square-wave was produced after the test probe was properly compensated.*

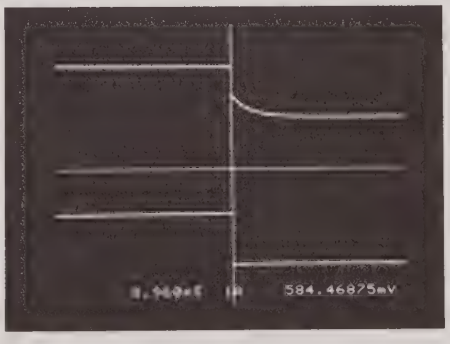
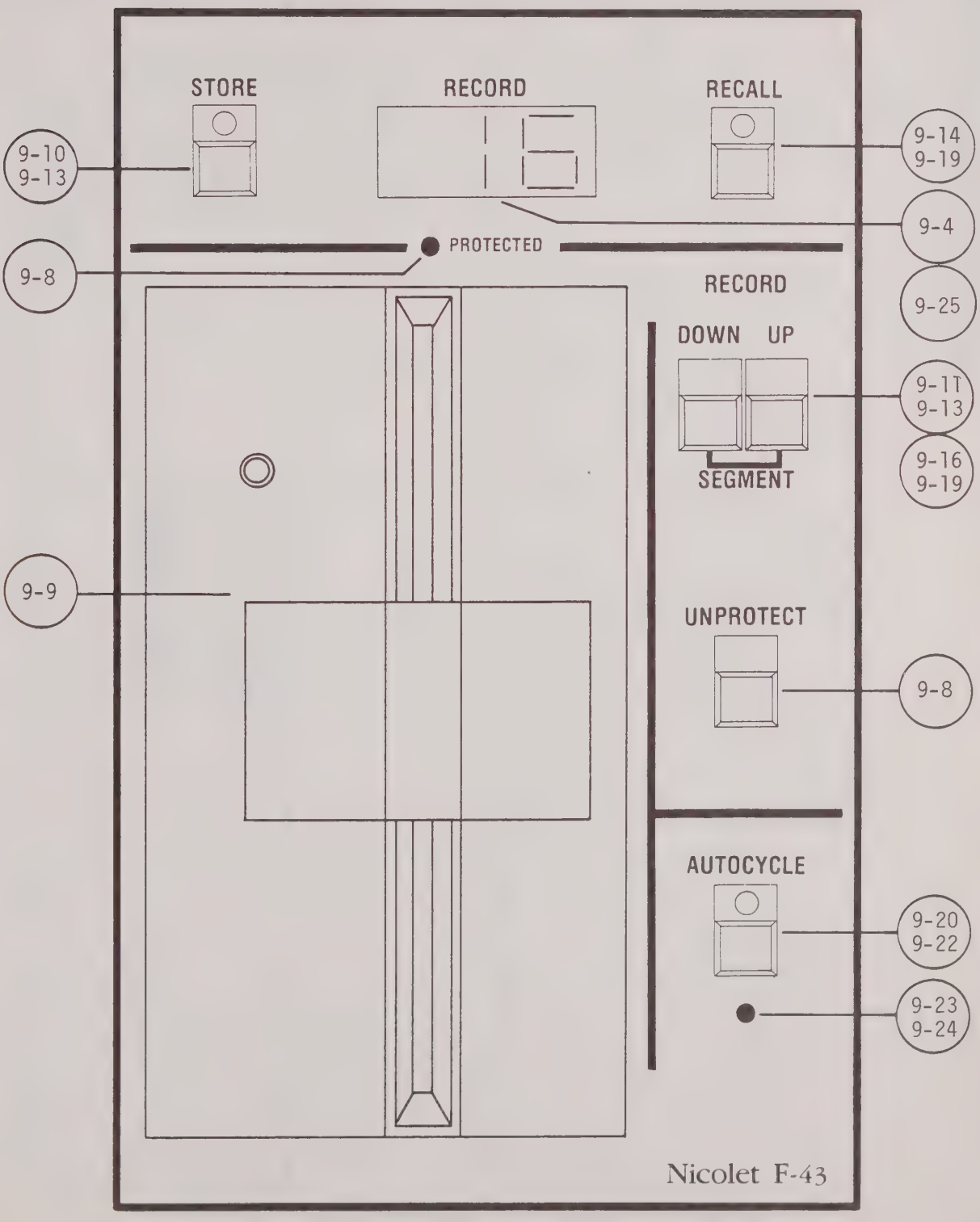



*Figure 8-44*

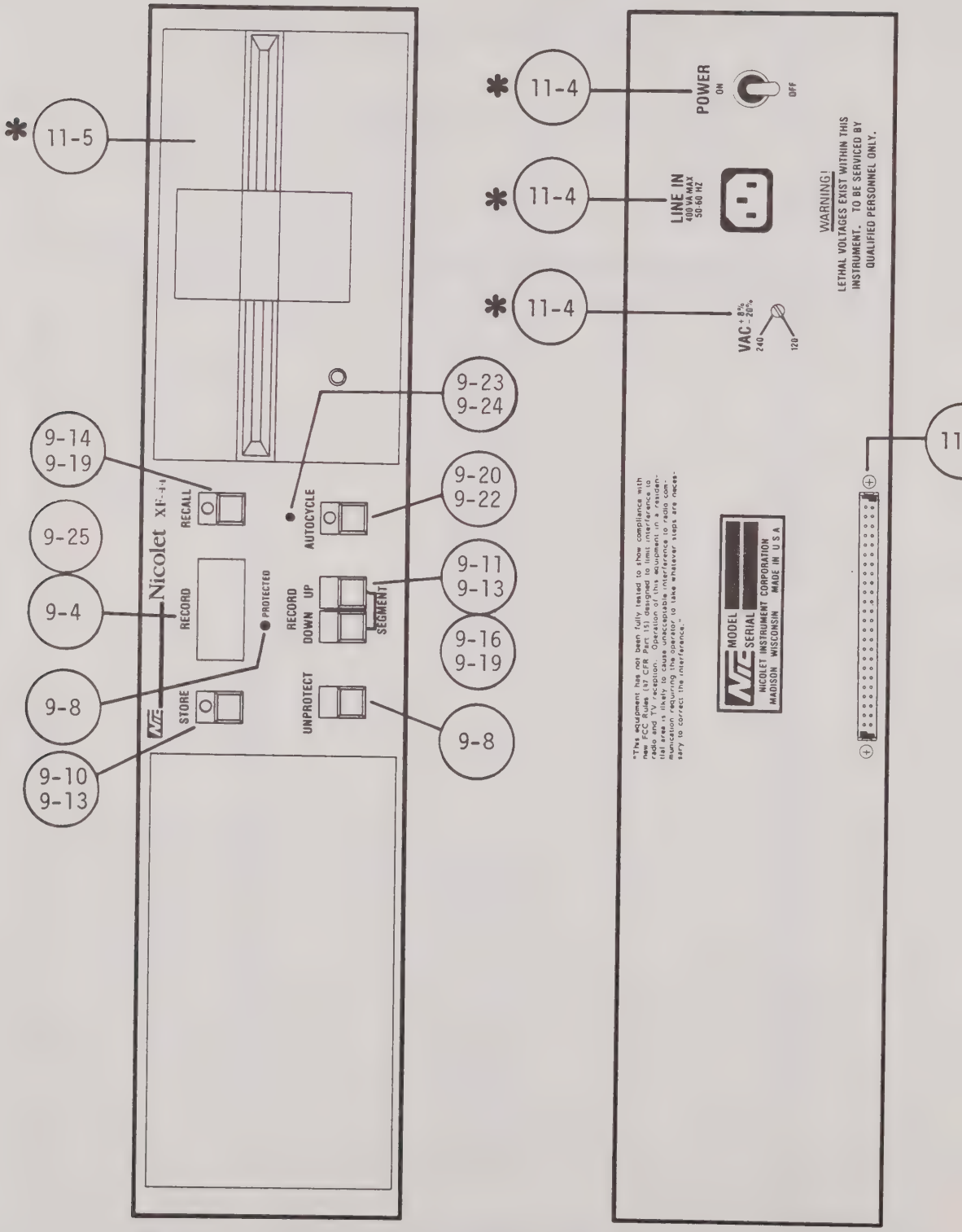
*Exact spec's to be verified.

# Disk Recorder—F-43




NOTE: The operation of the Model XF-44/1 is identical to that of the Model F-43. See reverse side of this tab for the XF-44/1 configuration.

# Disk Recorder—XF-44/1




* REFER TO "DUAL DISK RECORDERS" TAB

## INTRODUCTION

The Disk Recorder transfers data onto the floppy diskette for storage. The stored data can be recalled at a later time for inspection on the screen.

The diskette is divided into twenty individual records. Each record is capable of storing either a single (16K), two (8K), or four (4K) data groups.

### DATA STORE METHODS

The operator can record data by any of the following procedures.

- Normal Store Routine

Data groups are sequentially stored on identical segments of each record until all twenty records have stored a data group.

- Segmented Store Mode

Data groups are stored on each segment of the record before incrementing to the next record.

- Autocycle Routine

Data groups are automatically stored at the end of a sweep. The oscilloscope will be rearmed into the Live/Hold Next modes upon completion of storage.

### DATA RECALL METHODS

The operator can recall data by either of the following methods.

- Normal Recall Routine

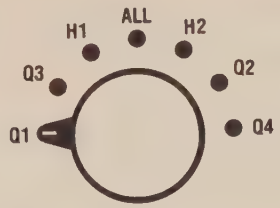
Used to recall either all or part of the data stored in a single record. This method also allows data stored in different records (but not in identical segments) to be recalled and displayed for comparison.

- Segmented Recall Mode

Used to recall data stored on different tracks (but in identical segments) and display them on the screen for comparison.

### FORMAT ROUTINE

Divides floppy diskettes, purchased from different suppliers, into the twenty individual records required by the Series 4094 oscilloscope to store data.




MEMORY

## MEMORY SWITCH (Mainframe Front Panel)

Determines whether the selected diskette record will remain intact (ALL) or divide into either "halves" (H1 or H2) or "quarters" (Q1, Q2, Q3, or Q4).

The MEMORY switch is located on the Mainframe's front panel.

DOWN UP

SEGMENT

## DOWN PUSHBUTTON

Decrements the displayed record and/or segment by a factor of (1).

## UP PUSHBUTTON

Increments the displayed record and/or segment by a factor of (1).

## SEGMENT PUSHBUTTONS

Each segment of the selected record stores a data group before the diskette increments to the next record. Enables data groups stored on identical segments, but in different records, to be "mixed" during the Recall routine.

The Segmented mode is activated by simultaneously pressing the UP and DOWN pushbuttons.

## NUMERICAL DISPLAY

The following information will be displayed on the numerical display.

- RECORD NUMBER - For a Series 4094 diskette, numbers 01 thru 20. For Series 2090 diskette, numbers 1 thru 8 (leading zero is suppressed).
- SEGMENT - Either H1, H2, F1, F2, F3, or F4 alternates with the selected record number when operating in the Segmented Store/Recall modes or in the Autocycle routine.
- FORMAT MODE - The word "For" appears, formatting an entire diskette.
- ERROR FLAGS - The letter "E" alternates with an error code number.

## PROTECTED LED

Alerts the operator, when LED is illuminated, that the record/segment selected to store data is already holding data.

## UNPROTECT PUSHBUTTON

Allows previously stored data to be replaced by overriding the automatic protection feature.

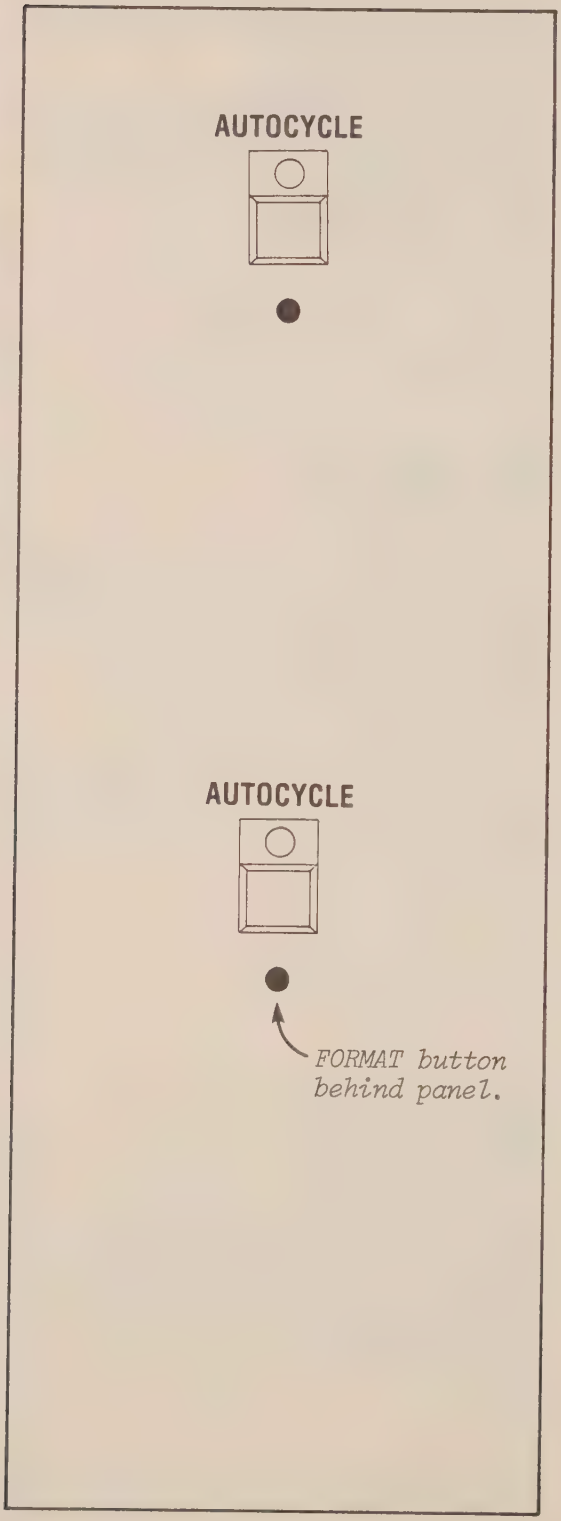
## STORE PUSHBUTTON

Transfers data from the display memory to the diskette for storage. The LED indicator illuminates during the transfer of data.

It is also used to activate the Format routine after the FORMAT push-button is pressed.

## RECALL PUSHBUTTON

Transfers data from the diskette to the display memory for viewing. The LED indicator illuminates during the transfer of data.




## AUTOCYCLE PUSHBUTTON

Data automatically transfers from the display memory to the diskette each time the Plug-in's Live/Hold Next LEDs turn off and the Hold Last LED turns on. The Plug-in returns to the Live/Hold Next modes after the data has transferred.

Repressing the AUTOCYCLE pushbutton exits the Autocycle routine and turns off the LED indicator.

## FORMAT PUSHBUTTON

Divides a new, unformatted diskette into twenty individual records. The STORE pushbutton must also be pressed to activate the Format routine.

The FORMAT pushbutton is mounted behind the Disk Recorder's front panel. It is operated by inserting a small diameter instrument into the access hole located below/above the AUTOCYCLE button.

Pressing the FORMAT pushbutton a second time aborts the Format routine.

## THE DISKETTE

The Series 4094 diskette stores data for recall at a later time and is divided into twenty individual records. Each record can store up to (16K) data points of digitized data and can be left intact or divided into subgroups referred to as "segments."

►IMPORTANT: A Series 2090 diskette can not be formatted, nor can it store data on an F-43/XF-44 disk recorder. It can, however, be used to recall 2090 oscilloscope into the 4094 memory.

The position selected on the MEMORY switch (Mainframe panel) determines whether or not a record will be divided:

- ALL
  Each record remains intact, storing a single (16K) data group; twenty data groups per diskette.
- H1 or H2
  Each record divides into "halves." Two (8K) data groups can be stored on a record; forty data groups per diskette.
- Q1, Q2, Q3, or Q4
  Each record divides into "quarters." Four (4K) data groups can be stored on a record; eight data groups per diskette.

*EXAMPLE #9-1*

*Figure 9-1 illustrates the three record configurations (intact, halves, and quarters) that can be selected by the MEMORY switch.*

*NOTE: The "quarter" segments are prefixed by the letter (F) on the numerical display instead of the (Q) designations on the MEMORY switch.*

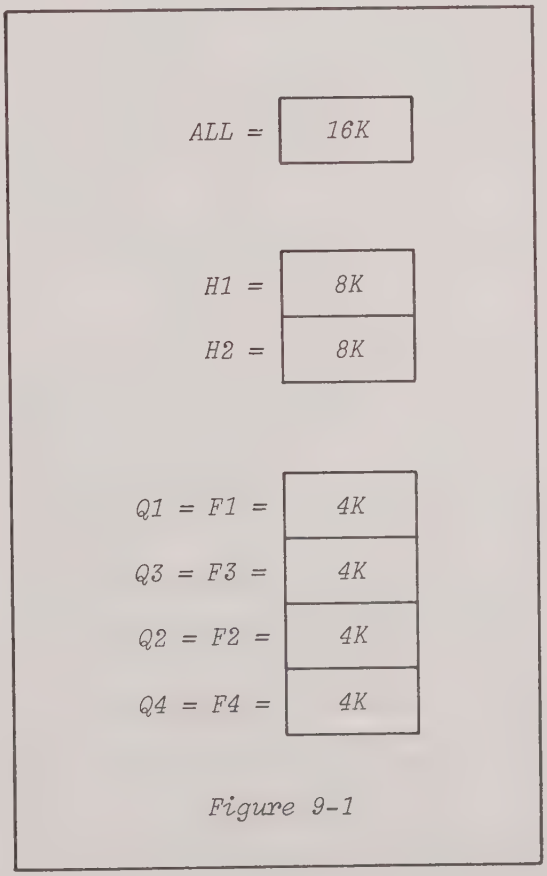



*Figure 9-1*

● DATA PROTECTION

►IMPORTANT: The data protection features are NOT designed to protect data if the diskette is subjected to magnetic fields, or any other conditions that may adversely affect the diskette and/or recorded data.

● Automatic Protection

Protect marks are automatically registered for each data group stored on the diskette and are identified by an illuminated PROTECTED LED. The operator can quickly determine whether or not the entire record is protected by switching the MEMORY switch and observing the PROTECTED LED.

The word "Pro" will appear on the numerical display if the STORE button is pressed while the PROTECTED LED is illuminated. To clear the numerical display, press the UP/DOWN button.

A protected Record/Segment can be unprotected by pressing the UNPROTECT button. An entire diskette can be quickly unprotected by selecting Record 01 and then pressing and holding in the UNPROTECT button. The diskette will not "ring-around" from Record #20 to Record #01.

● Tab Protection

Affixing a protect tab over the rectangular notch (Figure 9-2) allows data to be recalled, but not replaced. The PROTECTED LED remains illuminated when a tab protected diskette is inserted into the disk recorder.

The protect tab must be removed before attempting to perform an Unprotect/Store/Autocycle/Format/Copy routine. Otherwise, the word "Pro" will appear on the numerical display. To clear the word "Pro" from the numerical display, press the UP/DOWN button.

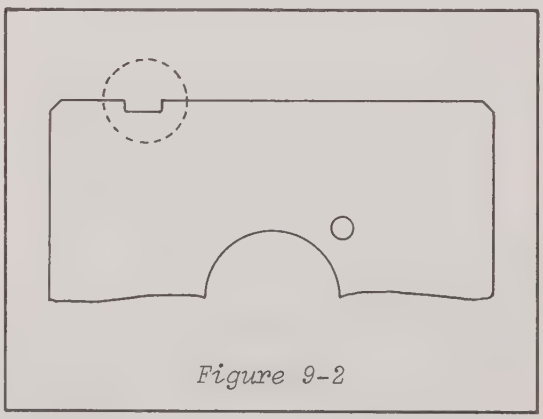


*Figure 9-2*

● LOADING THE DISKETTE

The disk drive automatically energizes when the diskette is inserted into the disk recorder.

The numerical display will illuminate only if the diskette has been formatted and it is either a Series 2090 or 4094 diskette.

► IMPORTANT: The drive's door must be closed within 3 seconds after the diskette has been inserted into the disk recorder. Otherwise, the recorder will not acknowledge the presence of the diskette.

To insert the diskette:

#1. Open the small door at the front of the disk recorder. (Door should already be open - see CAUTION note on this page.)

#2. Position the diskette as shown in Figure 9-3.

#3. Slide the diskette into the disk recorder.

#4. Close the door within 3 seconds after inserting the diskette.

The diskette is removed by opening the door and pulling the diskette out.

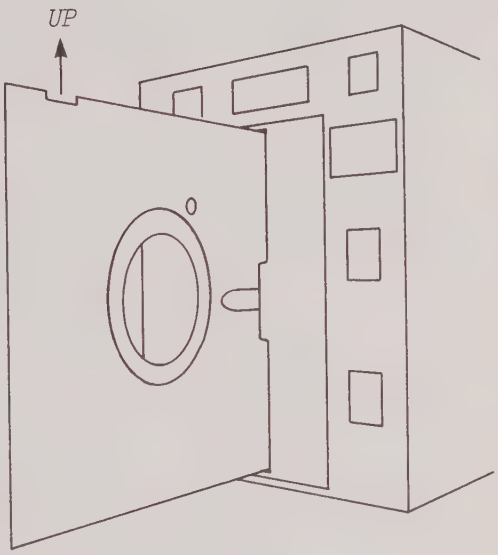



*Figure 9-3*

WARNING: To guard against physical damage to the disk heads and/or diskette, ALWAYS open the drive's door when:

a. Power is off, or
b. Applying/removing power, or
c. Drive is not being used, or
d. Transporting the instrument.

## STORE ROUTINE

Data transfers from the display memory to the diskette each time the STORE button is pressed. The Plug-in should be in the Hold mode for proper operation.

The disk recorder automatically increments to the next record each time the STORE button is pressed and the data group has been stored. The "beeper" announces each time the diskette "rings-around" from Record #20 to Record #01.

The UNPROTECT button must be pressed, before initiating a Store routine, if a protected data group is to be replaced. A protected data group is identified by an illuminated PROTECTED LED and can be bypassed by pressing the UP/DOWN button.

● SELECTING A RECORD TO STORE DATA

A specific record can be selected to store the data group by pressing the UP/DOWN button and observing the numerical display.

● SELECTING A SEGMENT TO STORE DATA

The position selected on the MEMORY switch determines which Segment of the record will store the data group.

- ALL
  Stores one (16K) data group on the entire record.
- H1 or H2
  Stores one (8K) data group on the segment selected.
- Q1, Q2, Q3, or Q4
  Stores one (4K) data group on the segment selected.

● NORMAL STORE ROUTINE PROCEDURE

#1. MEMORY switch: Select segment.

#2. UP/DOWN button: Select record number on numerical display.
   a. If PROTECTED LED illuminates, either bypass the record or press the UNPROTECT button.

#3. STORE button: Press.
   a. STORE LED illuminates during transfer of data.
   b. Recorder increments diskette to next record after the data group has been stored.

*EXAMPLE #9-2*

*Assume that the MEMORY switch is in the "H1" position; a protected data group is stored on Record #20 - Segment H1; and the first of two (8K) data groups is to be stored on Record #19.*

*Figure 9-4 illustrates the sequence of storing the data groups, one at a time. Record #20 was manually bypassed with the UP button.*

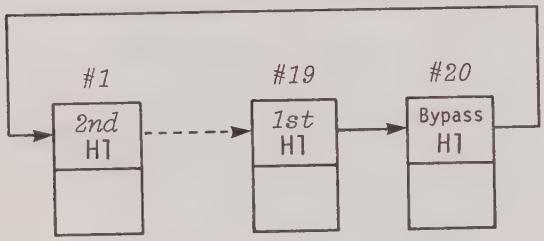



*Figure 9-4*

SEGMENTED STORE MODE

Allows the recorder to sequentially access consecutive segments of an entire Record before incrementing the diskette to the next Record.

● ACTIVATING THE SEGMENTED MODE

Activated by simultaneously pressing the UP/DOWN buttons.

● DEACTIVATING THE SEGMENTED MODE

Deactivated by simultaneously pressing the UP/DOWN buttons a second time.

● SELECTING A RECORD TO STORE DATA

The Record Number displayed on the numerical display while holding in both the UP and DOWN buttons will be the Record at which Segmented mode is entered. Pressing the UP (or DOWN) button causes the numerical display to increment (decrement) in segments, (F# or H#).

The Segmented mode must be exited if a specific Record Number is to be selected, or verified. A specific Record can be selected by exiting the Segmented mode and pressing the UP/DOWN button while observing the numerical display.

● SELECTING A SEGMENT SIZE

Each Record can be divided into either "halves" or "quarters." Which of these two sizes will be selected is determined by the position of the MEMORY switch at the time that the Segmented mode is activated.

- ALL
  Not allowed. Already provided for by the Normal Store routine.
- H1 or H2
  Each record divides into "halves," storing two (8K) data groups; forty data groups per diskette. The Record Number will be replaced by either an H1 or H2 designation on the numerical display.
- Q1, Q2, Q3, or Q4
  Each record divides into "quarters," storing four (4K) data groups; eighty data groups per diskette. The Record Number will be replaced by either an F1, F2, F3, or F4 designation on the numerical display.

The operator can bypass a Segment designation displayed on the numerical display by pressing either the UP or DOWN button.

● Equal Segment Sizes

Only equally sized segments can be selected to store data while operating in the Segmented mode. (e.g., If the MEMORY switch was in the H1/H2 position when the Segmented mode was activated, then data can only be stored on one half of the record.)

The recorder will automatically exit the Segmented mode if the operator reselects a larger/smaller segment size on the MEMORY switch and attempts to store data. The word "Err" will appear on the numerical display while the STORE button is pressed and then be replaced by a Record Number when the button is released.

● Mixing Segment Sizes

A data group can be recorded on a larger/smaller segment than was initially selected by exiting the Segmented mode, selecting the new segment size on the MEMORY switch, and then reactivating the Segmented mode. This is accomplished by:

#1. UP/DOWN buttons: Press both.

#2. MEMORY switch: Select new size.

#3. UP/DOWN buttons: Press both.

● SEGMENTED STORE PROCEDURE

#1. UP/DOWN button: Increment/ decrement numerical display until desired Record Number is displayed.

#2. MEMORY switch: Select whether the record will be divided into "halves" (H1 or H2), or into "quarters" (Q1, Q2, Q3, or Q4).

#3. UP/DOWN buttons: Press both simultaneously and observe the numerical display to verify the selected Record Number.

#4. UP/DOWN buttons: Select which Segment of the record (displayed on the numerical display) will store the first data group.
   a. If the PROTECTED LED illuminates, either bypass the Record/Segment or press the UNPROTECT button.

#5. STORE button: Momentarily press.
   a. STORE LED illuminates during transfer of data.
   b. Disk Recorder increments to next Segment/Record.

*EXAMPLE #9-3*

*Assume that the MEMORY switch was in the H1 position when the Segmented mode as activated. Also assume that a protected data group is stored on Record #19 - Segment H2, and the first of five consecutive (8K) data groups is to be stored on Record #19 - Segment H1.*

*Figure 9-5 illustrates the sequence of storing each data group, one at a time. Record #19 - Segment H2 was manually bypassed by pressing the UP button.*

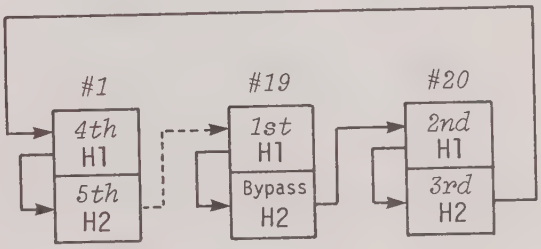



*Figure 9-5*

## RECALL ROUTINE

Data transfers from the diskette to the display memory each time the RECALL button is pressed.

NOTE: The Plug-in must be in the Hold mode when recalling data from the diskette. Otherwise, the word "Err" will appear on the numerical display when the RECALL button is pressed.

The data is recalled from the diskette according to the position selected on the MEMORY switch. The disk recorder automatically increments the diskette to the next record each time the RECALL button is pressed.

A record can be bypassed by pressing either the UP or DOWN button. The operator can scan through the diskette by pressing and holding in the RECALL button.

A "beeper" announces each time the diskette "rings-around" from Record #20 to #01.

### ● SELECTING A SEGMENT TO RECALL DATA

The position selected on the MEMORY switch will allow the data stored within that segment to be recalled when the RECALL button is pressed.

- ALL
  Recalls one (16K), two (8K), or four (4K) data groups.
- H1 or H2
  Recalls one (8K), or two (4K) data groups.
- Q1, Q2, Q3, or Q4
  Recalls one (4K) data group from the selected segment.

*EXAMPLE #9-4*

*Assume four (4K) data groups are stored on a single record.*

*Four (4K) data groups can be recalled by selecting the "ALL" position.*
*ALL = (F1, F2, F3 and F4).*

*Two (4K) data groups can be recalled by selecting a "halves" position.*
*H1 = (F1 & F3). H2 = (F2 & F4).*

*One (4K) data group will be recalled according to the segment selected on the MEMORY switch.*
*Q1 = F1. Q2 = F2. Q3 = F3. Q4 = F4.*

● SELECTING A RECORD TO RECALL DATA

A specific record can be selected to recall either all of the data stored on it, or only a segment of the data. The record number will be displayed on the numerical display and can be incremented/decremented by using the UP/DOWN buttons.

The operator can elect to scan the entire diskette for a specific display by pressing and holding in the RECALL button.

The operator can also elect to recall data stored on different records, but NOT on identical segments (e.g., all on Segment H1) and display them superimposed on the screen for comparison. This is accomplished by recalling and storing each data group, one at a time, in a different display memory subsection and then placing the MEMORY switch to the "ALL" position.

*EXAMPLE #9-5*

*Assume that four (16K) data groups stored on Records #1, #3, #7, and #9 are to be compared on the screen.*

*The following sequence illustrates the proper procedure of transferring one fourth of each data group and storing each one in a different display memory subsection.*

| | | |
|---|---|---|
| *#1.* | *Numerical Display:* | *Select "01"* |
| *#2.* | *MEMORY switch:* | *Q1* |
| *#3.* | *RECALL button:* | *Press.* |
| *#4.* | *Numerical Display:* | *Select "03"* |
| *#5.* | *MEMORY switch:* | *Q3* |
| *#6.* | *RECALL button:* | *Press.* |
| *#7.* | *Numerical Display:* | *Select "07"* |
| *#8.* | *MEMORY switch:* | *Q2* |
| *#9.* | *RECALL button:* | *Press.* |
| *#10.* | *Numerical Display:* | *Select "09"* |
| *#11.* | *MEMORY switch:* | *Q4* |
| *#12.* | *RECALL button:* | *Press.* |
| *#13.* | *MEMORY switch:* | *ALL* |

*The operator can now view all four (4K) data groups superimposed on the screen, but at a lower (4K) resolution per waveform.*

SEGMENTED RECALL MODE

The Segmented Recall mode allows the operator to "mix" data groups which are stored on different Records, but on identical Segments, (e.g., all stored on Segment H1).

● ACTIVATING THE SEGMENTED MODE

Activated by simultaneously pressing the UP/DOWN buttons.

● DEACTIVATING THE SEGMENTED MODE

Deactivated by simultaneously pressing the UP/DOWN buttons.

● SELECTING A RECORD TO RECALL DATA

The Record Number displayed on the numerical display while holding in both the UP and DOWN buttons will be the Record at which Segmented mode is entered. Pressing the UP (or DOWN) button causes the numerical display to increment (decrement) in segments, (F# or H#).

The Segmented mode must be exited if a specific Record Number is to be selected, or verified. A specific Record can be selected by exiting the Segmented mode and pressing the UP/DOWN button while observing the numerical display.

● SELECTING A SEGMENT SIZE

Data can be recalled from either a half or a quarter of the record. Which of these two segment sizes will be selected is determined by the position of the MEMORY switch at the time that the Segmented mode is activated.

- ALL
  Not allowed. Already provided for by the Normal Store routine.
- H1 or H2
  Each record divides into "halves," recalling one (8K), or two (4K) data groups. The Record Number will be replaced by either an H1 or an H2 designation on the numerical display.
- Q1, Q2, Q3, or Q4
  Each record divides into "quarters," recalling one (4K) data group. The Record Number will be replaced by either an F1, F2, F3, or F4 designation on the numerical display.

The operator can bypass a Segment designation displayed on the numerical display by pressing either the UP or DOWN button.

• Selecting a Different Segment Size

The operator can reselect a larger/smaller segment size to recall its data by exiting the Segmented mode; selecting the new segment size on the MEMORY switch; and then reactivating the Segmented mode. This is accomplished by:

#1. UP/DOWN buttons: Press both simultaneously to exit the Segmented mode.

#2. MEMORY switch: Select the new segment size.

#3. UP/DOWN buttons: Press both simultaneously to reenter the Segmented mode.

If the above procedure is not used, the recorder will automatically exit the Segmented mode when the RECALL button is pressed. The word "Err" will appear on the numerical display while the RECALL button is pressed and then be replaced by a Record Number when the button is released.

*EXAMPLE #9-6*

*Assume that the MEMORY switch was in the "H1" position when the Segmented mode was activated.*

*The recorder will only be allowed to recall data from either Segment H1 or H2, depending upon which segment designation is being displayed on the numerical display. The recalled data can consist of either a single (8K), or up to two (4K) data groups.*

*If the operator wanted to recall only a single (4K) data group rather than the (8K) data group that would be recalled due to the "H1" position selected on the MEMORY switch, it will be necessary to perform the three step procedure listed at the left.*

● SEGMENTED RECALL PROCEDURE

#1. MEMORY switch: Select the position which corresponds to the desired Segment size and the Display Memory Subsection in which the first, recalled data group is to be stored.

#2. UP/DOWN buttons: Increment/ decrement the numerical display until the desired Record Number appears.

#3. UP/DOWN buttons: Press both simultaneously to enter the Segmented mode.

#4. UP/DOWN buttons: Increment/ decrement the numerical display until the desired Segment designation appears.

#5. RECALL button: Press.

#6. UP/DOWN buttons: Press both simultaneously to exit the Segmented mode.

#7. MEMORY switch: Select the position which corresponds to the desired Segment size (typically the same size as selected in Step #1) and the Display Memory Subsection in which the next, recalled data group is to be stored.

#8. Repeat Steps #2 thru #8 until all of the desired data groups have been recalled and stored in the Display Memory's Sub-sections.

#9. UP/DOWN buttons: Press both simultaneously to exit the Segmented mode.

#10. MEMORY switch: ALL

a. The recalled data groups will be displayed super-imposed on the display screen.

*EXAMPLE #9-7*

*Assume four (4K) data groups (one each stored on Segment F1 of Records #1, #3, #7 and #9) are to be recalled and superimposed on the display screen.*

*#1. MEMORY switch: Q1*

*#2. UP/DOWN buttons: Increment/ decrement numerical display until Record Number (01) appears.*

*#3. UP/DOWN buttons: Press both.*

*#4. Numerical Display: Increment/ decrement display until (01*/F1) appears.*

*#5. RECALL button: Press.*

*#6. MEMORY switch: Q3*

*#7. Numerical Display: Increment display until (03*/F1) appears.*

*#8. RECALL button: Press.*

*#9. MEMORY switch: Q2*

*#10. Numerical Display: Increment display until (07*/F1) appears.*

*#11. RECALL button: Press.*

*#12. MEMORY switch: Q4*

*#13. Numerical Display: Increment display until (09*/F1) appears.*

*#14. RECALL button: Press.*

*#15. MEMORY switch: ALL*

*#16. UP/DOWN buttons: Press both simultaneously to exit the Segmented mode.*

*(*) The Record Number can be verified by exiting the Segmented mode. If incorrect, increment/decrement the numerical display until the correct Record Number appears and then reactivate the Segmented mode.*

## AUTOCYCLE ROUTINE

Data is automatically acquired by the Plug-in and then transferred from the display memory to the diskette at the end of each sweep.

The Plug-in alternates between the Live/Hold Next (data acquisition) mode and the Hold (data transfer) mode until Record #20 has stored (16K) words of data.

NOTE: The diskette does not "ring-around" from Record #20 to Record #01 in the Autocycle routine.

● SELECTING THE FIRST RECORD

Any one of the twenty records can be selected to store the first data group by pressing either the UP or DOWN button and observing the numerical display.

The recorder will store (16K) words of data on each record, starting with the record selected to store the first data group and ending with Record #20.

NOTE: The protect tab (if affixed) must be removed from the diskette. The operator must unprotect all of the records selected to store data in the Autocycle routine, otherwise the word "Pro" will appear on the numerical display when the AUTOCYCLE button is pressed.

#1. Numerical Display: Display the Record Number which is to store the first data group.

#2. MEMORY switch: ALL

#3. UNPROTECT button: Press and hold in until each record, through Record #20, is unprotected.

#4. Repeat Step #1.

● SELECTING THE SEGMENT SIZES

Whether each record will store one, two, or four data groups is determined by the position of the MEMORY switch at the time that the Autocycle routine is activated.

- ALL
  Each record remains intact, storing a single (16K) data group.
- H1 or H2
  Each record divides into "halves," storing two (8K) data groups.
- Q1, Q2, Q3, or Q4
  Each record divides into "quarters," storing four (4K) data groups.

The Autocycle routine must be exited to reselect a larger/smaller segment.

● ACTIVATING THE AUTOCYCLE ROUTINE

Activated by pressing the AUTOCYCLE button.

➤ IMPORTANT: Previously acquired data must be stored on the diskette before activating the Autocycle routine. Otherwise, it will be replaced by the first Autocycle sweep.

● DEACTIVATING THE AUTOCYCLE ROUTINE

The Record Number selected to store the first data group will reappear on the numerical display when the Autocycle routine is exited. The Autocycle routine will deactivate when -

#1. Record #20 has stored (16K) words of data, or

#2. Any of the Disk Recorder's buttons are pressed and held until the AUTOCYCLE LED turns off.

The operator can identify on which Record/Segment the Autocycle routine was aborted by -

#1. MEMORY switch: ALL

#2. UP button: Increment numerical display until first unprotected record number appears.

#3. DOWN button: Decrement the numerical display by one record.

#4. MEMORY switch: Switch between each position and observe the PROTECTED LED.
   a. If the LED remains illuminated for each position, the next record is the one on which the Autocycle routine was aborted. Increment the numerical display by one record.

*EXAMPLE #9-8*

*Assume Record #05 was selected to store the first data group; the operator unprotected Records #05 through #20; and the MEMORY switch was in the "ALL" position when the AUTOCYCLE button was pressed.*

*#1. Plug-in enters Live/Hold Next mode.*

*#2. Valid trigger occurs, initiating a sweep.*

*#3. Plug-in enters Hold mode at the end of the sweep.*

*a. Data transfers to the Record Number appearing on the numerical display, (Record #05 for the first data group).*

*b. Numerical display increments to next Record Number.*

*#4. Steps #1 through #3 repeat until Record #20 stores a data group.*

*a. Recorder exits Autocycle.*

*b. Record #05 reappears on the numerical display.*

*Figure 9-6: Storing successive data groups according to the position selected on the MEMORY switch.*

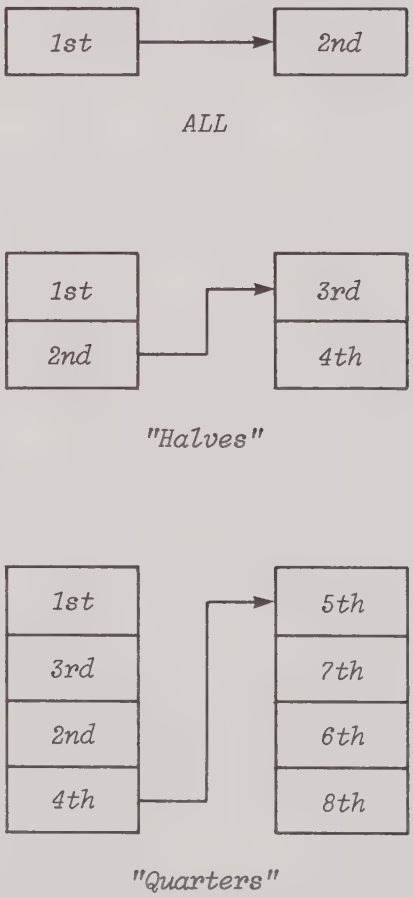



*Figure 9-6*

## FORMAT ROUTINE

►IMPORTANT: Only 80 track, 96 TPI, double sided diskettes can be formatted on the F-43 Disk Recorder. The diskettes shipped with the Series 4094 oscilloscopes have been pre-formatted at the factory. A series 2090 diskette can not be formatted.

● ENTERING THE FORMAT ROUTINE

The Format routine divides the diskette into the required twenty records and takes approximately three minutes for completion.

The Format routine is armed by pressing the FORMAT button (accessed via the hole adjacent to the AUTOCYCLE button) with a small diameter instrument. The word "For" will appear on the numerical display when the routine has been successfully armed.

The actual formatting process will not start until the STORE button is pressed.

NOTE: The STORE button must be pressed within 45 seconds after arming the Format routine. Otherwise, the routine will be automatically unarmed if the time period is allowed to elapse.

● EXITING THE FORMAT ROUTINE

The recorder automatically exits the Format routine after the diskette has been formatted. The STORE LED will turn off and the word "For" will be replaced with a Record Number.

The Format routine can be manually unarmed (BEFORE the STORE button is pressed) by pressing any button, (including the FORMAT, but not the STORE button) on the Disk Recorder.

● TAB PROTECTED DISKETTES

The tab must be removed. Otherwise, the word "Pro" will appear on the numerical display when the operator attempts to arm the Format routine.

NOTE: A misaligned disk drive and/or head may cause erroneous Store/Recall routines which may resemble a faulty disk recorder. Therefore, it is recommended that a factory formatted diskette be kept unaltered to help verify the proper operation of the disk recorder.

Return the diskette to the place of purchase if the recorder has been verified operational and the diskette in question can not be formatted after a second attempt.

● FORMATTING DISKETTES

#1. Insert the diskette into the Disk Recorder.
   a. Disk drive energizes.

#2. Insert a small diameter instrument into the hole adjacent to the AUTOCYCLE button.
   a. The word "For" appears on the numerical display.

   NOTE: If the word "Pro" appears, remove the tab from the diskette and repeat Steps #1 and #2.

#3. Press the STORE button within 45 seconds after performing Step #2.
   a. The STORE LED illuminates and the Disk Recorder begins the formatting process.
   b. Upon completion, the STORE LED turns off and the word "For" is replaced on the numerical display by a Record number.

## ERROR CODES

The following is a tabulation of Error Codes which will appear on the numerical display in the event of an erroneous operation.

An Error Code can be cleared by momentarily pressing either the UP or DOWN button.

### ERROR WORDS

- Pro - Attempting to -
  - #1. Store/Format/Copy/Unprotect/Autocycle on a tab protected diskette, or
  - #2. Attempting to Store or Autocycle on a protected record.
- Err - Attempting to -
  - #1. Recall data while the Plug-in is in the Live mode, or
  - #2. Store/recall data (while in the Segmented mode) from a larger/smaller Segment than was initially selected, or
  - #3. Unprotect either a 2090 or a Program diskette.

### ERROR NUMBERS

- E3 - CRC data error. (e.g., Check sum error.) Try again.
- E4 - CRC data ID error. (e.g., Check sum error.) Try again.
- E5 - Either a bad diskette (try again) or the diskette being used is not a 4094 diskette.
- E6 - Either a bad diskette (try again), or the diskette being used is not a 4094 diskette, or no diskette is present in the disk recorder.
- E7 - Either a broken drive and/or broken drive cable.
- E8 - Diskette being used is not 4094 formatted.
- E9 - Disk Program not understood. Try again.
- E10 - Disk Program not understood. Try again.
- E11 - Disk Program not understood. Try again.

## INTRODUCTION

The Model 4094 oscilloscope can be operated with two Plug-ins, providing up to four channel operation.

The second Plug-in will be located in the F-43 Disk Recorder bay.

The 4562 and 4851 Plug-ins can be mixed or matched in any combination. The operation of the Plug-ins remain identical to that as previously described under the *Plug-ins* tab.

However, since the Mainframe is sharing its capabilities with up to four channels, the following descriptions should be read to properly apply the dual Plug-in mode of operation.

NOTE: The term "Hold mode" will be used to indicate that the Plug-in(s) have exited the Live mode; only the Hold Last LED is illuminated.

## MEMORY ADDRESS ALLOCATION

The number of activated channels and the position of the MEMORY switch determines the number of allotted addresses that will record the captured input signals. See Table 10-1.

| NUMBER OF CHANNELS | MEMORY SWITCH | | |
|---|---|---|---|
| | ALL | H1/H2 | Q1 - Q4 |
| 1 | *15,872* | *7,936* | *3,968* |
| 2 | *7,936* | *3,968* | *1,984* |
| 3 | *5,290* | *2,645* | *1,322* |
| 4 | *3,968* | *1,984* | *922* |

*Table 10-1*

## SWEEP TIMES

The sweep times will decrease when multiple channels are activated.

Refer to *Plug-ins* tab, Page 8-17, Table 8-4 (for the appropriate Plug-in) and divide the listed sweep times accordingly:

Two channels ---------- (2)
Three or four channels --------- (4)

## MASTER TRIGGERING

A valid trigger applied to the Master Plug-in also triggers a sweep at the Slave Plug-ins.

The trigger must be applied to the "Master" Plug-in and the position selected on the "Master" Plug-in's SOURCE switch (A, B, or EXT) must correspond accordingly.

The remaining Plug-in(s) are referred to as the "Slave" Plug-ins. The SOURCE switch(es) must be placed to the "S" position(s).

## MIXING TRIGGER DISPLAYS

The operator can select any combination of Normal, Cursor, and Delayed trigger displays. Each channel operates independently.

# Disk Recorder—XF-44/2




* REFER TO "DISK RECORDER" TAB

## INTRODUCTION

The optional NICOLET XF-44/2 Dual Disk Recorder is typically used to record signals acquired by the Model 4094 Digital oscilloscope. However, an important, additional feature of the XF-44/2 is its ability to easily copy data from one diskette onto another.

The basic operation of this accessory is essentially identical to that of the F-43 and XF-44/1 Disk Recorders described under tab *Disk Recorders*.

However, due to several operational exceptions and added features, the following descriptions should be read.

NOTE: The left-hand drive will be referred to as *DRIVE 0*. And the right-hand drive will be *DRIVE 1*.

NOTE: The term "Hold mode" will be used to indicate that the Plug-in has exited the Live mode, only the Hold Last LED is illuminated.

WARNING: To guard against physical damage to the disk heads and/or diskette, ALWAYS open the drive's door when:

a. Power is off, or
b. Applying/removing power, or
c. Drive is not being used, or
d. Transporting the instrument.

## RIBBON CABLE CONNECTOR

Use the ribbon cable furnished with the XF-44 Disk Recorder and interface the two instruments as shown in Figure 11-1.

NOTE: The ribbon cable connectors are keyed on the 4094 and XF-44 as illustrated in Figure 11-1.

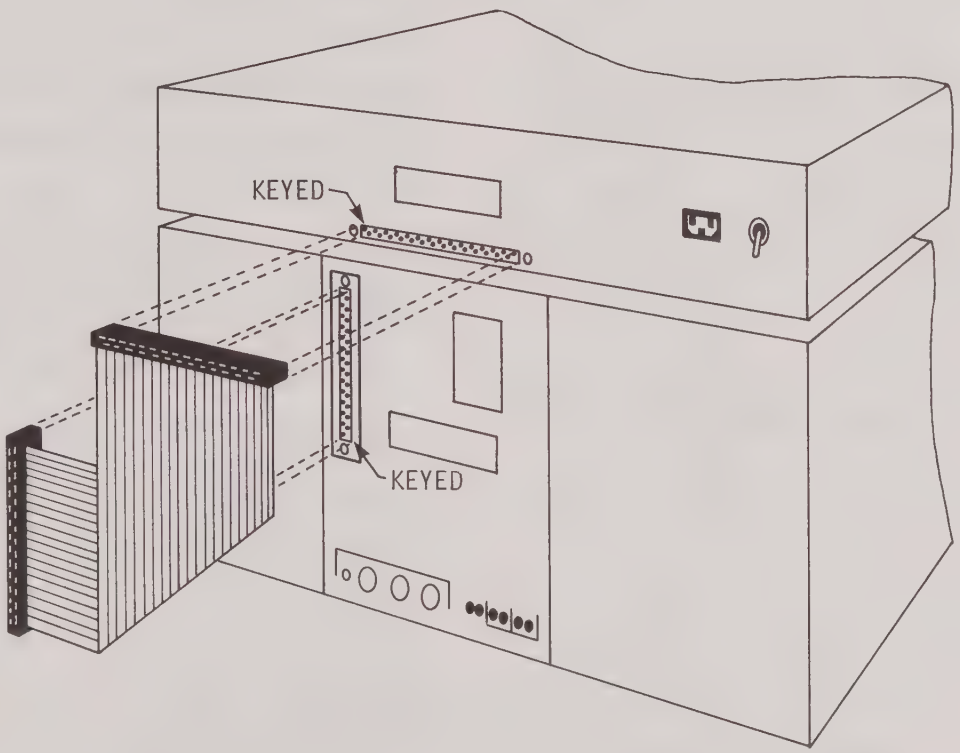



*Figure 11-1*

## POWER REQUIREMENTS

A POWER selector is located on the rear panel of the XF-44.

The position of the XF-44's POWER selector must correspond to that which is selected on the 4094's selector.

> WARNING: Always ensure that the position of the XF-44's POWER selector corresponds to that of the 4094's POWER selector before applying power to either unit.

For additional information on the POWER selectors, refer to *POWER REQUIREMENTS*, located under the tab labeled *Receiving & Pwr Req's*.

The low voltage logic commands between the XF-44 and 4094 are interconnected via the ribbon cable leading between the two instruments.

The ribbon cable also provides power to a relay inside of the XF-44. This relay applies line power to the Disk Drives as soon as the 4094 is turned on. The XF-44's POWER switch must be in the "ON" position.

## POWER SWITCH

The POWER: ON/OFF switch mounted on the back of the XF-44 has been provided as a servicing aid. It should always be left in the "ON" position during normal operation.

Placing the POWER switch to the "OFF" position is designed to remove line power from the disk drives. The low voltage logic power will remain via the ribbon cable.

> WARNING: Lethal voltages exist within the XF-44. It should be serviced only by qualified personnel. Remove all power from this instrument before servicing. Reapply power only after all safety measures have been observed.

IMPORTANT: If power is to be removed from the XF-44 during "normal" operation, it should be removed by turning the 4094 off. This procedure is designed to remove line power from the disk drives and logic power from the circuitry during normal operations. Removing power by any other means may cause the disk heads to drift, causing erroneous operations.

## LOADING THE DISKETTE(S)

The disk drive(s) automatically energize when the diskette(s) are inserted. Position the diskettes as shown in Figure 11-2.

A Record Number appears on the numerical display if the diskettes have been formatted and are either Series 2090 or 4094 diskettes.

► IMPORTANT: The drive's door must be closed within 3 seconds after the diskette has been inserted. Otherwise, the Disk Recorder will not recognize the presence of the diskette.

Table 11-1 tabulates the Record Numbers which will be displayed, corresponding to the type of diskette and into which disk drive it is inserted.

NOTE: When loading two diskettes into an XF-44/2, load one at a time and observe the numerical display for a confirming Record Number before inserting the second one. If a Record Number does not appear, the diskette must be formatted.

| TYPE OF DISKETTE | DISK DRIVES | |
|---|---|---|
| | DRIVE 0 | DRIVE 1 |
| 2090 | *1 - 8* | *1_1 - 1_8* |
| 4094 | *01 - 20* | *101 - 120* |

*Table 11-1*

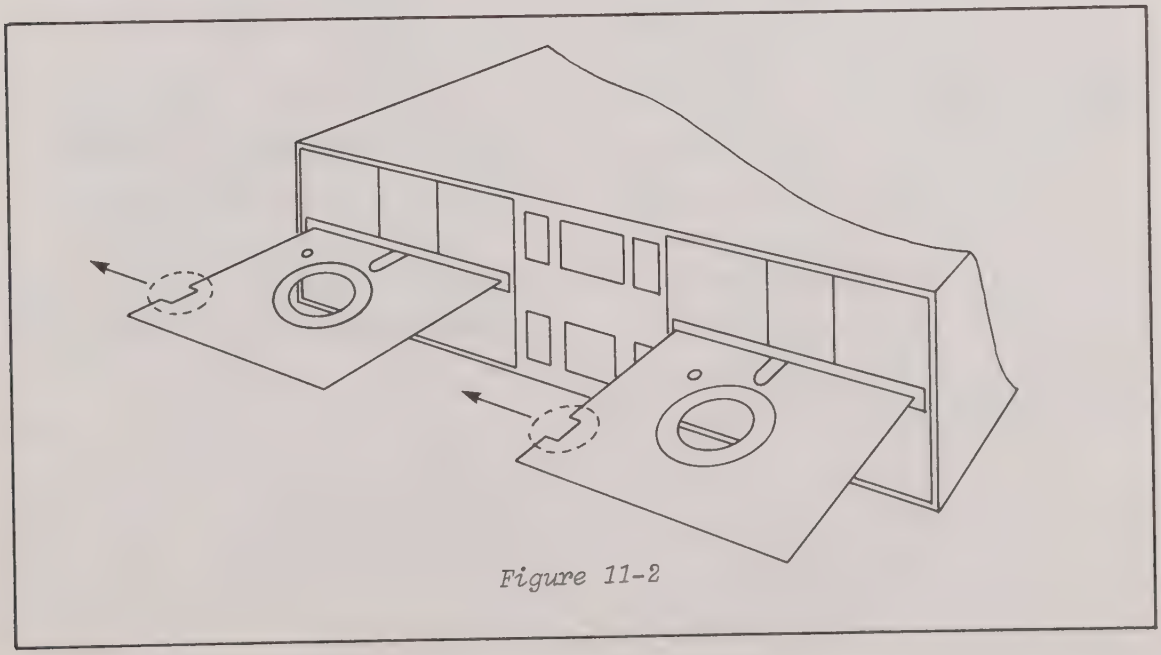


*Figure 11-2*

## NUMERICS DISPLAY

The numerics display will display the the Record Numbers in the following manner, according to which drive the diskette is placed and the type of diskette being used.

- 2090 Diskette
  - Drive 0: Records 1 thru 8
  - Drive 1: Records 1_1 thru 1_8
- 4094 Diskette
  - Drive 0: Records 01 thru 20
  - Drive 1: Records 101 thru 120
- Program Diskette
  - Drive 0: P01 thru P99, max.
  - Drive 1: P01 thru P99, max.

## RECORDING SIGNALS

If the oscilloscope is operating with two or more Plug-ins, each Plug-in must be in the Hold mode before data will transfer from the Mainframe's display memory to the XF-44 for storage on the diskette(s).

## AUTOCYCLING THE DISKETTES

The XF-44 can operate as either a single or dual disk drive when in the Autocycle routine.

- SINGLE DRIVE: The diskette must be placed in *DRIVE 0*. The Record Number selected to store the first data group, up through Record #20, must be unprotected or the word "Pro" will appear on the numerical display when the AUTOCYCLE button is pressed.
- DUAL DRIVES: Either drive can be selected to record data first. The recorder does not step between the two drives when one diskette becomes filled with data. The operator must manually select which drive will record data.

  The Record Number selected to store the first data group, up through Record #20, must be unprotected. Otherwise, the word "Pro" will appear on the numerical display when the AUTOCYCLE button is pressed.

## FORMAT ROUTINE

The Format routine divides a diskette into the required twenty records. It takes approximately three minutes to complete the Format routine.

►IMPORTANT: Only 80 track, 96 TPI, double sided diskettes can be formatted on the XF-44/2 Disk Recorder.

Diskettes shipped with the Series 4094 oscilloscopes have already been formatted at the factory.

►IMPORTANT: Either disk drive can be used to format a diskette. However, ensure that the unused disk drive does not contain a diskette to guard against the possibility of formatting the wrong diskette.

The Format routine is armed by pressing the FORMAT pushbutton (accessed via the hole adjacent to the AUTOCYCLE pushbutton) with a small diameter instrument. The word "For" will appear on the numerical display. Pressing the STORE pushbutton will then initiate the Format routine.

NOTE: The Recorder automatically unarms the Format routine if the STORE button is not pressed within 45 seconds after the FORMAT routine has been armed.

The word "Pro" will appear on the numerical display if the operator attempts to Format a tab protected diskette. The tab must be removed in order to Format the diskette.

Pressing the FORMAT pushbutton a second time exits the Format routine.

A misaligned disk drive and/or head may cause erroneous Store/Recall routines which may resemble a faulty disk recorder.

It is recommended that a factory formatted diskette be kept unaltered to help verify the proper operation of the disk recorder.

Return the diskette to the place of purchase if the disk drive and head have been verified operational and the diskette in question can not be formatted after a second attempt.

## COPYING DISKETTES

Data stored on one diskette can be duplicated on another when the XF-44/2 is used in conjunction with the *DISKETTE COPY* program selected on the Disk Programs diskette.

The entire diskette must be copied; individual records can not be selected for duplication.

To copy a diskette -

#1. Insert the Program Diskette into either of the two drives.
   a. A letter "P" and program "number" appears on the numerical display.

#2. UP/DOWN buttons: Press until "P01" (Catalog Number) appears on the numerical display.

#3. RECALL button: Press.
   a. The phrase PROGRAM "CATALOG" appears on the status line at the top of the display screen.

#4. FUNCTION switch: PRGM

#5. EXECUTE button: Press.
   a. The Catalog Program becomes resident in the Program Memory.

#6. CURSOR Up/Down button: Press until the desired Program and Program Number appears on the status line. The Program Number will also appear on the numerical display.

#7. EXECUTE button: Press.
   a. The Catalog Program exits the Program Memory.

#8. RECALL button: Press.
   a. The selected Program becomes resident in the Program Memory.

#9. Remove the Program Diskette.

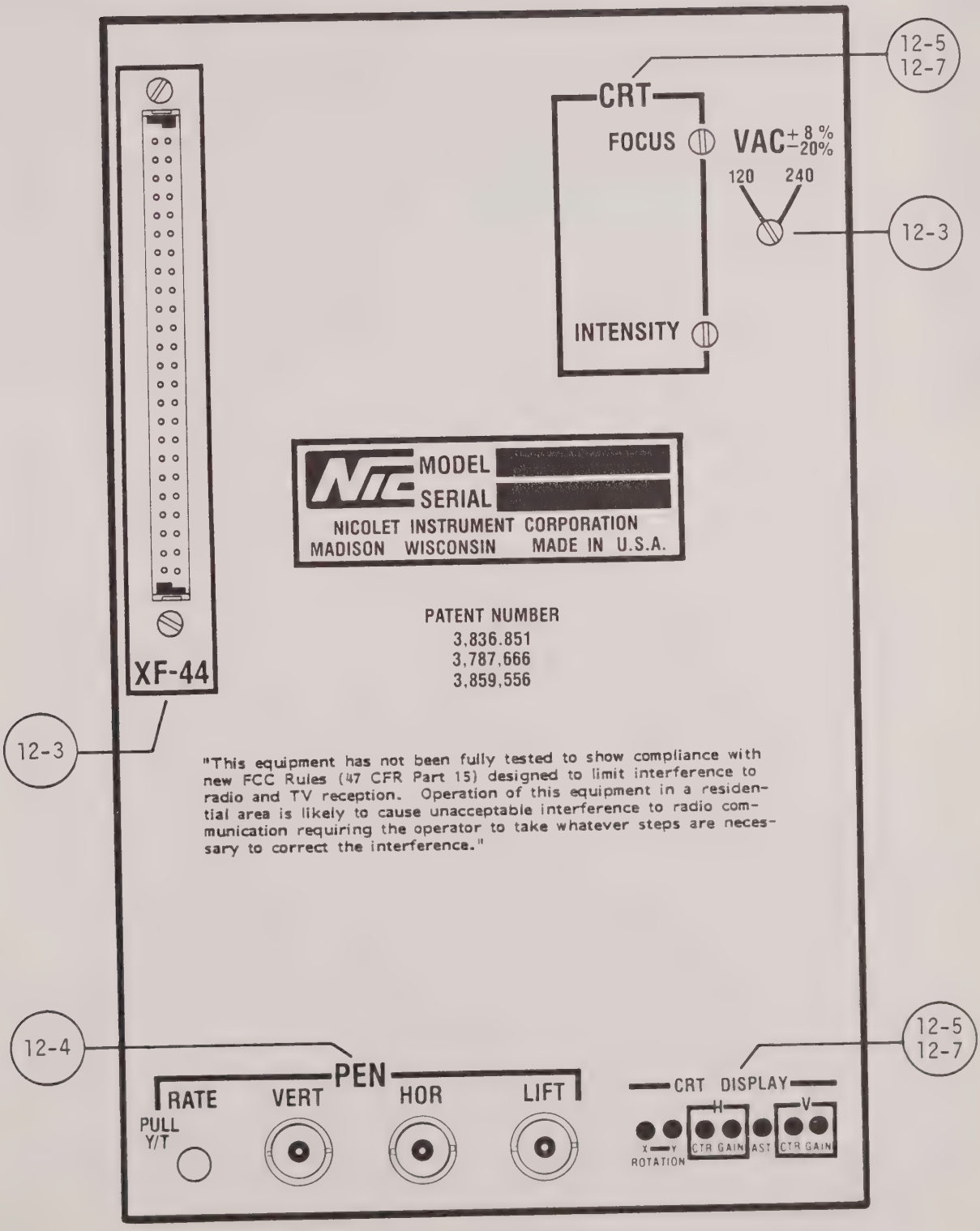
#10. Insert the master diskette into *DRIVE 0*.

#11. Insert the duplicating diskette into *DRIVE 1*.

#12. EXECUTE button: Press.
   a. The data stored on the master diskette is duplicated on the blank diskette.

► IMPORTANT: The *DISKETTE COPY* program will remain resident in the Program Memory until either the power is removed from the 4094 or the Program is replaced by a different program.

# Back Panel

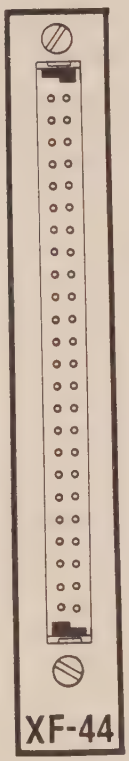

12-5
12-7
CRT
FOCUS
VAC +8% -20%
120
240
12-3
INTENSITY
MODEL
SERIAL
NICOLET INSTRUMENT CORPORATION
MADISON WISCONSIN MADE IN U.S.A.
PATENT NUMBER
3,836,851
3,787,666
3,859,556
XF-44
12-3
"This equipment has not been fully tested to show compliance with new FCC Rules (47 CFR Part 15) designed to limit interference to radio and TV reception. Operation of this equipment in a residential area is likely to cause unacceptable interference to radio communication requiring the operator to take whatever steps are necessary to correct the interference."
12-4
PEN
RATE
VERT
HOR
LIFT
PULL Y/T
CRT DISPLAY
H
V
X
Y
ROTATION
CTR
GAIN
AST
CTR
GAIN
12-5
12-7

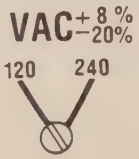
## INTRODUCTION

The Mainframe's back panel contains an XF-44 interface connector, power selector switch, controls for either an XY or YT pen recorder, and controls to adjust the CRT display.

This section of the manual will primarily deal with the CRT display alignment controls and recommended procedures.

The remaining controls have been previously described and are referenced to the appropriate sections of this manual for more detailed information.




## XF-44 CONNECTOR

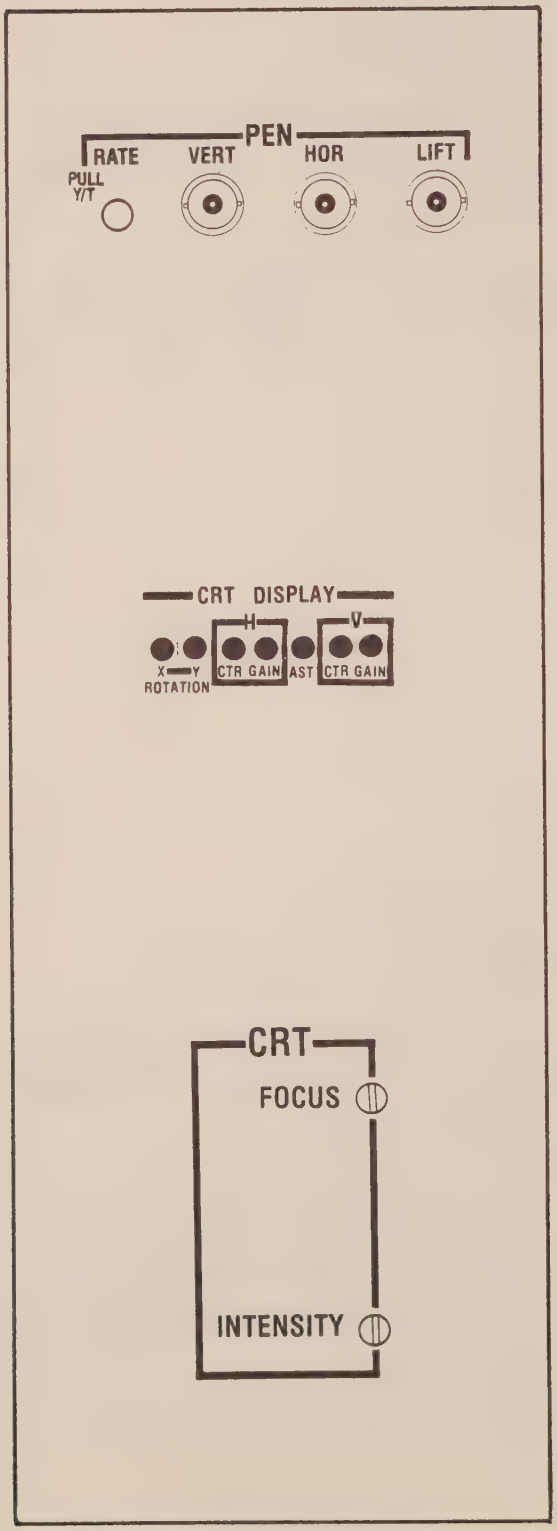
Interfaces the Model 4094 oscilloscope to the XF-44 Dual Disk Recorder via a ribbon cable.

Refer to tab *Dual Disk Recorders*, page 11-3 for further information.

## POWER SWITCH

Select according to the line voltage that will be used to power the Model 4094 oscilloscope

> WARNING: Before applying power to this instrument, refer to the *Receiving & Pwr Req's* tab, page 5-2.




## PEN CONTROLS

Provides output and control of an XY or YT pen recorder.

Refer to tab *Mainframe*, page 7-33 for further information.

## CRT DISPLAY ADJUST

Adjusts the X and Y rotation, horizontal center and gain, vertical center and gain, and astigmatism.

## CRT ADJUST

Adjusts the CRT focus and intensity.

## DISPLAY ADJUSTMENTS

Figure 12-1 has been included as a "quick guide" which summarizes the function of each CRT display adjustment control. The following alignment procedure should be followed when aligning the CRT display.

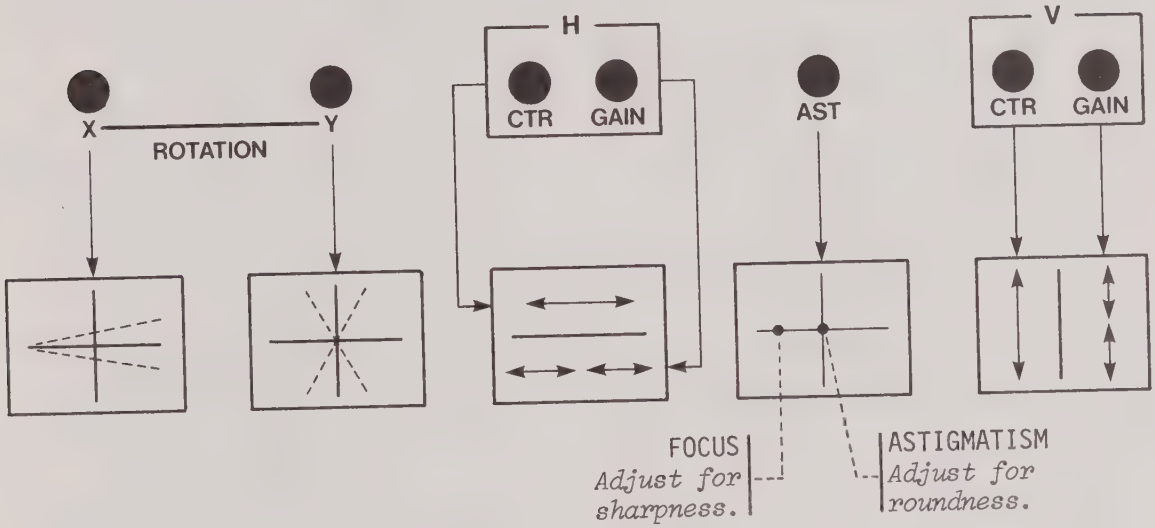



*Figure 12-1*

## DISPLAY ALIGNMENT

The CRT display alignment controls are accessible from the rear panel of the Mainframe.

● ALIGNMENT PROCEDURE

It is recommended that the following alignment procedure be followed in the sequence listed and align the CRT only when necessary.

#1. Place all DC/AC/GND switches to the "GND" position.

#2. Place the AUTO/NORM switch to the "AUTO" trigger position.

#3. Place the Plug-in into the Live mode.

#4. Place the VERTICAL and HORIZONTAL EXPANSION switches to the "X2" position.

#5. X-ROTATION: Rotates the entire display with the left side of the screen acting as the pivot.
   a. Adjust until the horizontal cursor is parallel with the bottom of the screen.

#6. Y-ROTATION: Rotates the entire display with screen center acting as the pivot.
   a. Adjust until the vertical cursor is parallel with the side of the screen.

#7. HORIZONTAL CENTER: Positions the display either left or right.
   a. Adjust until the horizontal cursor is evenly centered on the screen.

#8. HORIZONTAL GAIN: Expands or contracts the entire display.
   a. Adjust until both ends of horizontal cursor are approximately 3/16" from the sides of the screen.

#9. VERTICAL CENTER: Positions the display either up or down.
   a. Adjust until the vertical cursor is evenly centered on the screen.

#10. VERTICAL GAIN: Expands or contracts the entire display.
   a. Adjust until the vertical cursor is approximately 1/8" from the bottom of the screen.

#11. Repeat Steps #9 and #10 until the vertical cursor is approximately 1/4" from the bottom of the screen.

#12. Increase the HORIZONTAL EXPANSION switch setting until individual data points can be easily discerned.

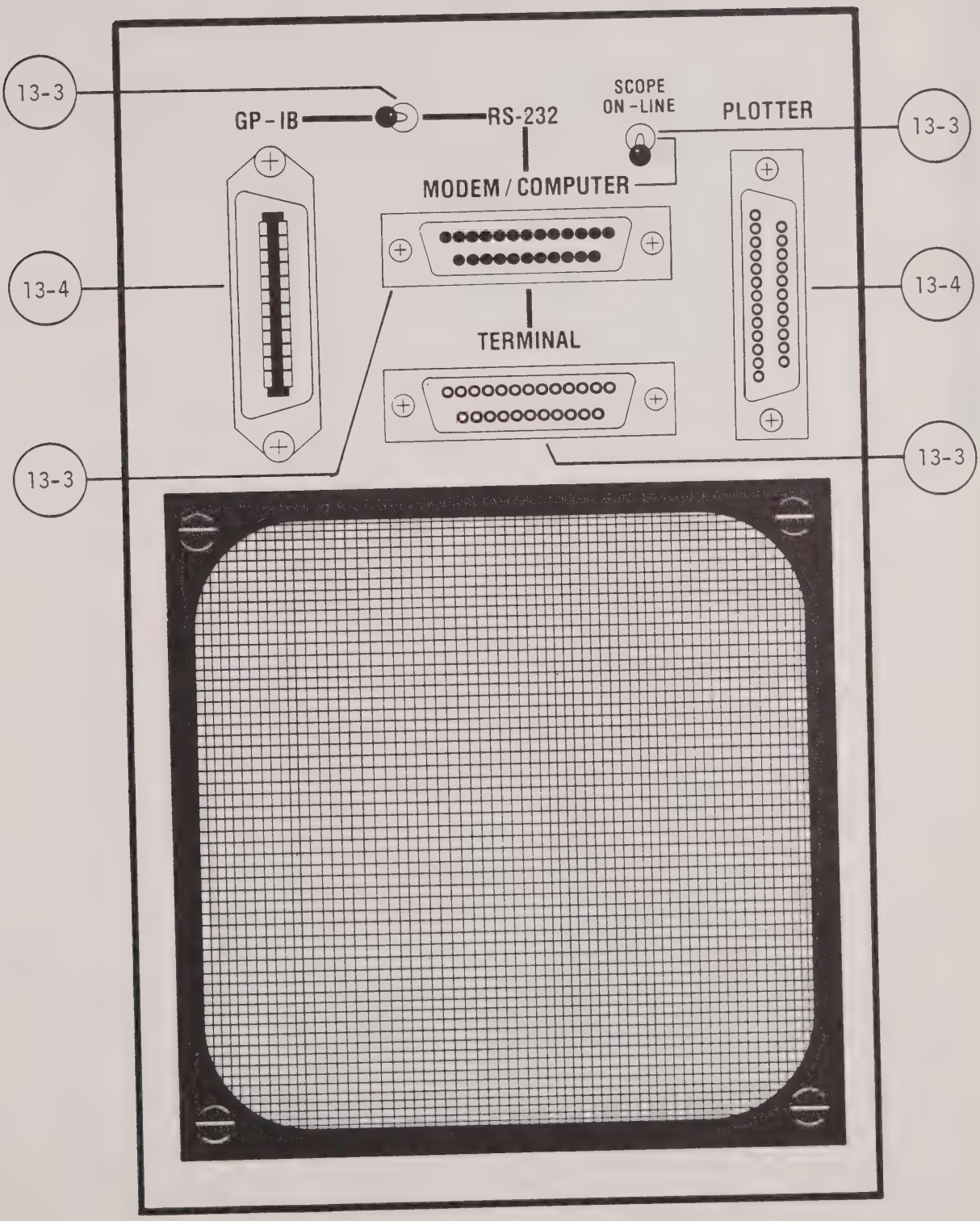
#13. Place the Mainframe into the Autocenter mode.

#14. ASTIGMATISM: Adjusts for round data points.
   a. Adjust until the data point at screen center is round.

#15. FOCUS: Adjusts for the sharpest data point detail.
   a. Locate a data point approximately 50% between screen center and the side of the display screen. Adjust the FOCUS until the data point is in focus.

#16. INTENSITY: Brightens or darkens the display. This control may be adjusted to obtain optimum results when photographing the display.

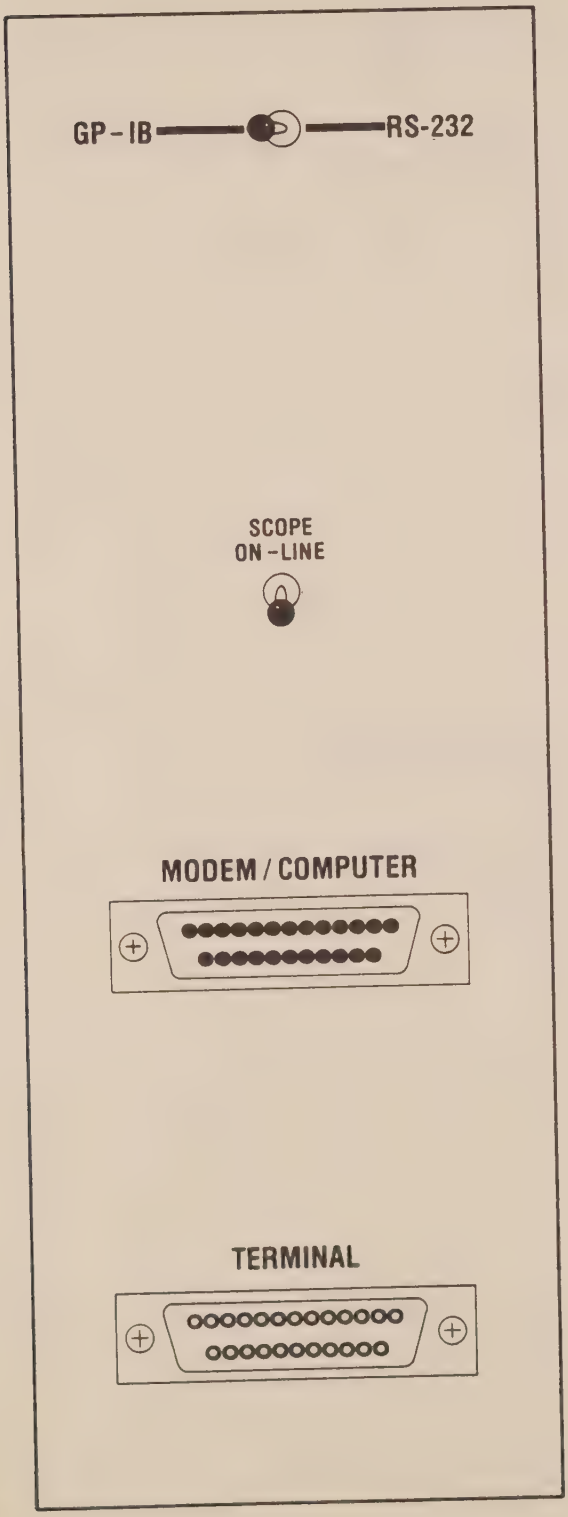
# Input/Output Panel



## INTRODUCTION

NOTE: Specific operating instructions are not available at this time. They will be immediately forwarded upon completion.

► IMPORTANT: Activating the Input/Output board will inhibit the use of the Plug-in's and Mainframe's front panel controls. This condition is identified by the presence of the letters "CC" under the Status Line on the display. See *Mainframe* tab, page 7-7 for location.




## GP-IB/RS-232 SWITCH

Determines whether the GP-IB or RS-232 computer interface connectors will be activated.

## SCOPE ON-LINE SWITCH

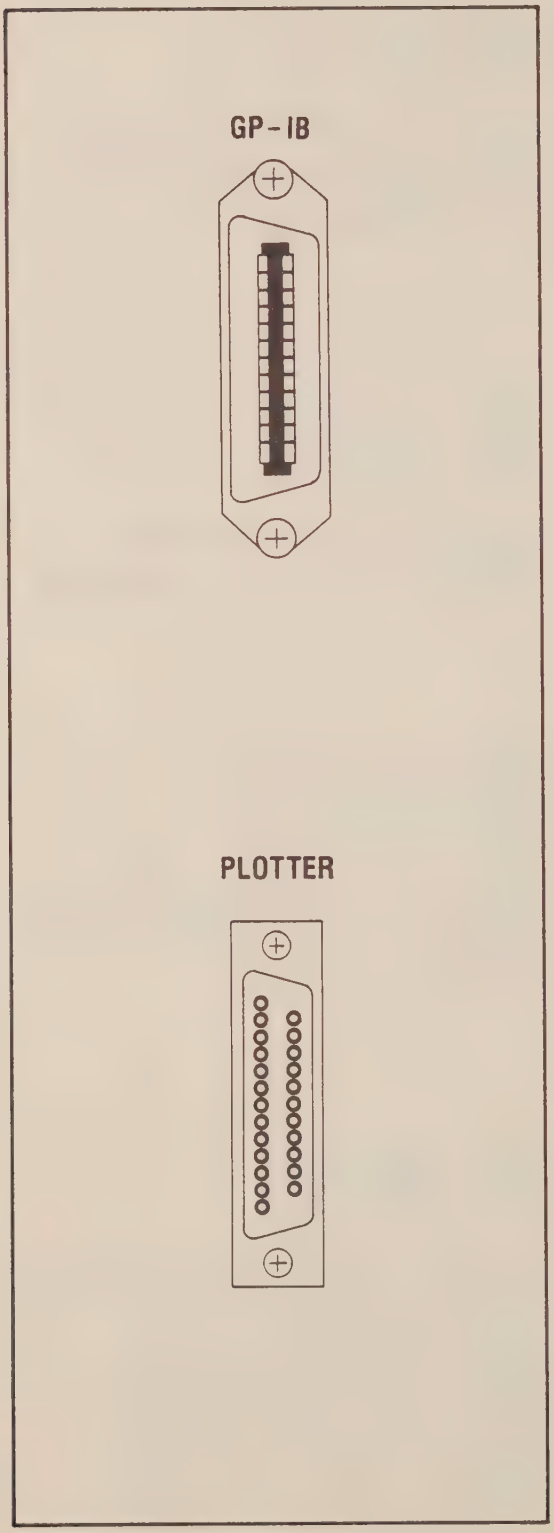
Activates the RS-232 computer interface connector when turned on.

## MODEM/COMPUTER CONNECTOR

Interfaces the computer, either directly or through a modem, to the 4094 oscilloscope.

## TERMINAL CONNECTOR

Interfaces an optional terminal, or other similiar device, to the computer. This connector only permits communication with the computer, it can not be used to control the 4094 oscilloscope.




## GP-IB CONNECTOR

Interfaces the computer to the 4094 oscilloscope.

## PLOTTER CONNECTOR

Interfaces the NICOLET X-90 Digital Plotter to the 4094 oscilloscope.

## INTRODUCTION

The Standard Pak programs are alphabetically prerecorded on the program diskette. These programs enable the operator to easily perform arithmetic and display manipulations, and are designed for use with the optional F-43 and/or XF-44 Disk Recorders.

Standard Pak programs can be duplicated when the XF-44/2 Disk Recorder is used in conjunction with the *DISKETTE COPY* program. (Refer to the *Dual Disk Recorders* tab, page 11-8.)

► IMPORTANT: To enable an easy means by which program results can be compared, (and enable both positive and negative program results to be displayed), waveforms will be automatically repositioned to the center of the screen, when noted in the corresponding program's specifications.

In addition, the POSITION control setting is automatically taken into account when the program is executed. If the waveform is not acquired at screen center, care must be taken not to exceed the ±Full Scale Attenuator setting.

*EXAMPLE #14-1*

*The waveform in Figure #1 was acquired with the ±Volts Full Scale switch in the ±10V position, and with a dc offset present at the input. Therefore, the maximum peak voltage may not exceed 10 volts. Otherwise, the resulting "wrapped-around" waveform displayed in Figure #2 will occur.*

*Peak voltages can be easily verified by positioning the vertical cursor across the waveform while observing the voltage numerics.*

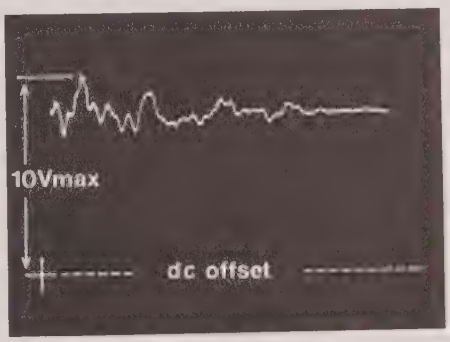



*Figure #1*

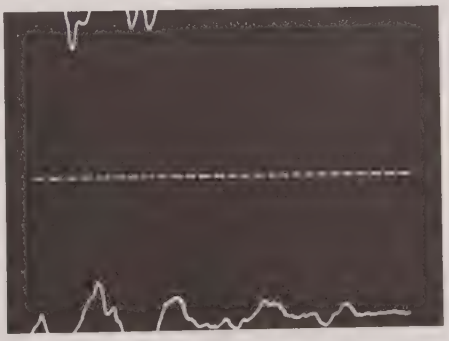


*Figure #2*

## INTRODUCTION

►IMPORTANT: The following tabulation of programs (and accompanying descriptions) correspond to the Version (1.0) program diskette, only. The Version Identification number can be verified by inspecting the label affixed to the diskette:

PART # 177-160001-1.0

The Version Identification number also appears at the end of the program titled *CATALOG* when that program is selected for display on the Status Line of the display screen, (e.g., Catalog -1.0).

| PROGRAM NUMBER | PROGRAM TITLE | PROGRAM NUMBER | PROGRAM TITLE |
|---|---|---|---|
| P01 | Catalog - 1.0 | P13 | Invert |
| P02 | Absolute Value | P14 | Maximum |
| P03 | Addition X+Y=Y | P15 | Minimum |
| P04 | Area | P16 | Multiply |
| P05 | Average Value | P17 | Rise Time |
| P06 | Aves., # of Sweeps | P18 | RMS |
| P07 | Centering Ø Volts | P19 | Scale 0-200% |
| P08 | Differentiation | P20 | Smoothing, 3 PT. |
| P09 | Diskette Copy | P21 | Subtraction X-Y=Y |
| P10 | Horizontal Shift | P22 | Title |
| P11 | Integration | P23 | Vertical Shift |
| P12 | Integration (AC) | | |

## INSERTING THE PROGRAM DISKETTE

The Program Diskette is inserted into the Disk Recorder in the same manner as previously described under the *Disk Recorder* tab, page 9-3; and the *Dual Disk Recorder* tab, page 11-5.

►IMPORTANT: The drive's door must be closed within 3 seconds after the diskette has been inserted. If the door is not closed within this time limit, the recorder will not recognize the presence of the diskette.

A properly inserted diskette is indicated by an illuminated numerical display with the letter "P" and program "Number."

If the time delay is exceeded before the door is closed, the diskette must be removed and then reinserted.

## PROGRAM MEMORY

The Program Memory, located on the I/O board, stores the selected Program. Once a Program has become resident within the memory, it will remain resident until either the power is removed from the 4094 or a new Program is entered.

NOTE: If desired and unless otherwise noted in the program descriptions, the Program Diskette can be removed from the disk recorder once a program has become resident in the program memory. No operation will be performed if the operator attempts to execute a program and a program is not resident in the memory.

## LOADING A PROGRAM INTO MEMORY

● SELECTING AN UNKNOWN PROGRAM

If the desired Program Number is not known, perform the following procedure.

#1. Insert the Program Diskette.
   a. A letter "P" and program "number" appears on the numerical display.

#2. Disk Recorder UP/DOWN buttons: Press until "P01" (Catalog Number) appears on the numerical display.

#3. RECALL button: Press.
   a. The phrase PROGRAM "CATALOG" appears on the status line at the top of the display.
   b. The Catalog Program becomes resident in the Program Memory. The diskette must remain in the disk drive.

#4. FUNCTION switch: PRGM

#5. EXECUTE button: Press.

#6. CURSOR Up/Down button: Press until the desired Program and Program Number appear on the status line. The Program Number will also appear on the numerical display.

#7. EXECUTE button: Press.
   a. The Catalog Program will be exited.

#8. RECALL button: Press.
   a. The selected Program becomes resident in the Program Memory.
   b. If desired, the Program Diskette may now be removed unless otherwise noted in the particular program description.

#9. EXECUTE button: Press.
   a. The Resident Program manipulates the displayed data, either automatically or via step-by-step instructions to the operator.

● SELECTING A KNOWN PROGRAM

If the desired Program Number is known, perform the following procedure.

#1. Insert the Program Diskette into the disk recorder.
   a. A letter "P" and program "number" appears on the numerical display.

#2. Disk Recorder UP/DOWN buttons: Press until the desired Program number appears on the numerical display.

#3. RECALL button: Press.
   a. The selected Program becomes resident in the Program Memory.
   b. If desired, the Program Diskette may now be removed unless otherwise noted under the particular program description.

#4. FUNCTION switch: PRGM

#5. EXECUTE button: Press.
   a. The Resident Program manipulates the displayed data, either automatically or via step-by-step instructions to the operator.

## DISK PROGRAM GENERAL OPERATION

Programs stored on the diskette can be used in any NICOLET Model 4094 Digital Oscilloscope which has a built-in (F-43) or external (XF-44) disk recorder. The programs are recalled from the diskette in the same manner as waveform data.

►IMPORTANT: Many programs modify the original data. If it is necessary to maintain the original waveform, it must be stored on a diskette, or elsewhere in the display memory, before executing a program.

In addition, some of the Disk Programs inhibit the use of the Plug-in's and Mainframe's front panel controls. The letters "CC" (Computer Control) will appear under the Status Line when this condition exits, see *Mainframe* tab, page 7-7 for location.

The numerical display indicates the program to be recalled (e.g., P01 indicates Program #1). To execute any program, it is necessary to recall it from the diskette, turn the FUNCTION switch to "PRGM," and then press the EXECUTE button.

Operator intervention required by a program will be requested on the display screen. Such requests must be actioned before the program is allowed to continue. Automatic selection of settings by the 4094 (resulting from previous operator selections or initial program usage) can be altered each time the program is executed.

If the 4094 oscilloscope has a dual disk recorder (XF-44/2), it is possible to keep a program diskette in one disk drive and a data diskette in the other. A single disk recorder (F-43 or XF-44/1) necessitates the removal and insertion of program and data diskettes as required.

Once a program has been recalled from a diskette, it can be used any number of times and will remain resident in the memory until a new program is recalled, or the oscilloscope is turned off. Program execution, initiated by pressing the EXECUTE button, is indicated by the green LED above the EXECUTE button.

Operation of the disk recorder is not possible while a program is being executed. Mixed data groups are not acceptable inputs to any program. Mixed data groups occur when two waveforms on the display were acquired using dissimilar sized fractions of memory. Two examples follow:

#1. One waveform is acquired in ALL. A second waveform is acquired in H2. Processing is attempted in ALL.

#2. One waveform is acquired in H1. A second waveform is acquired in Q3. Processing is attempted in H1.

Mixed data groups can be avoided by processing waveforms using the fraction of memory where they were acquired. Once a mixed data error has occurred, it can be corrected by turning the MEMORY switch to a smaller fraction of memory which contains the necessary waveform.

## DESCRIPTION

The CATALOG program contains an alphabetical list of all programs stored on the diskette.

NOTE: The Program Diskette must remain resident in the recorder during execution of the Catalog Program. In addition, the Catalog Program does not automatically recall any selected program from the diskette. Once the desired program is located, it is necessary to exit from the CATALOG program and recall the desired new program into memory.

The up/down CURSOR buttons allow the user to sequentially view the title of each program by observing the Status Line located at the top of the display screen. In addition, each program identification number is displayed on the numerical display, allowing a known program number to be easily selected.

The CATALOG program can be exited at any time by pressing the EXECUTE button.

## DESCRIPTION

ABSOLUTE VALUE repositions the selected waveform to screen center, changes the sign of the negative data values to positive, and thus displays the modified waveform.

►IMPORTANT: The resultant waveform replaces the original waveform in the memory.

The program prompts the user to select a starting point and an ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if ABSOLUTE VALUE is used repeatedly.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be modified, (use Autocenter to make the selection clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel acquired the waveform, (e.g., 1A = Plug-in #1/Channel A).

SPECIFICATIONS

a. Mainframe must be in YT.

b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

c. One waveform may be processed at a time.

## EQUATION

Computed Voltages = | Original Voltages |

Computed Time Base = Original Time Base

## DESCRIPTION

ADDITION moves the selected waveforms (X and Y) to the center of the screen, adds them together, and then displays the answer in the memory locations previously occupied by (Y). The resulting time numerics will be those of waveform (Y).

NOTE: Alignment of the X and Y time bases does not occur before addition. See the HORIZONTAL SHIFT program if time base alignment is necessary.

NOTE: The resultant waveform may not differ dramatically in physical size from the original waveform, but the numerics will be correct.

Waveforms X and Y must be selected by positioning the vertical cursor on the chosen waveform, (use Auto-center to make this clear).

It is important to remember that each waveform must have been acquired on the same effective voltage range, (voltage range x calibrated probe attenuation).

The time base of the result will be the same as the time base of the original (Y) waveform.

### SPECIFICATIONS

a. Mainframe must be in YT.

b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

## EQUATION

$X_n$ = Voltages on waveform X

$Y_n$ = Voltages on waveform Y

Computed $Y_n = X_n + Y_n$ (See note 1)

Computed Time Base = Time Base of Waveform Y

(Note 1: Vertical resolution is reduced by a factor of 2.)

## DESCRIPTION

AREA moves the selected waveform to the center of the screen, computes the area between the waveform and the horizontal cursor (point by point), and then displays the resulting waveform.

►IMPORTANT: The resultant waveform replaces the original waveform in the memory.

The program prompts the user to select a starting and an ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if AREA is used repeatedly.

When AREA is first recalled, the starting and ending points are automatically selected as the first and last points on the displayed waveform. Points lying outside of the chosen starting and ending points are zeroed after the AREA computation has been computed.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be manipulated, (use Autocenter to make the selection clear).

SPECIFICATIONS

a. Mainframe must be in YT.

b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

c. One waveform may be processed at a time.

The horizontal cursor sets the baseline for the area computation. Note that both positive and negative going values, as measured from the baseline, contribute to the computed waveform. Voltage x time at any point on the computed waveform expresses the area (e.g., millisecond volts) up to that point.

Mathematically, the area computation is similar to integration, but the resulting waveform will be different. The AREA program simplifies area computations by requiring the operator to multiply the two values shown on the screen (time and voltage) rather than the integrated voltage times the TIME PER POINT setting. Compare the AREA equation (reverse side) with that of INTEGRATION.

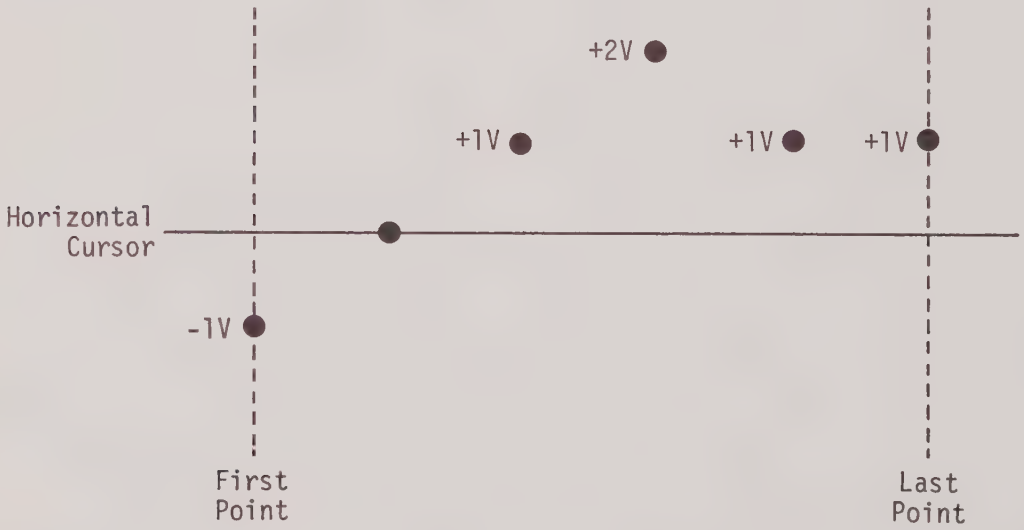
## EQUATION

$V_1$ = Selected First Point

$V_k$ = Selected Last Point

$$\text{Computed } V_n = \frac{V_n + V_{n-1} + V_{n-2} + \cdots\cdots V_1}{n} \quad \text{where } (1 \leq n \leq k)$$

## EXAMPLE




$$\text{Computed Voltage (at third point)} = \frac{1+0-1}{3} = 0V$$

$$\text{Computed Voltage (at last point)} = \frac{1+1+2+1+0-1}{6} = 0.66V$$

Computed Time Base = Time Base of Original Waveform

$$\text{Area from First to Last Point} = \left(\frac{-1+0+1+2+1+1}{6} \text{ volts}\right) \times (\text{time at last point})$$

## DESCRIPTION

AVERAGE VALUE moves the selected waveform to the center of the screen; computes the average voltage between the selected start and ending points and stores this value in the last data point of the waveform (far right side of screen); and then displays the average voltage with the horizontal cursor at the correct level. No other data points are changed.

Positive and negative waveform voltages are taken with respect to the original acquisition zero voltage level. The program requests a starting point and an ending point on the chosen waveform. Each point may be set by correctly positioning the vertical cursor and pressing the EXECUTE button. Selected starting and ending points remain in memory and are automatically recalled if AVERAGE VALUE is used multiple times.

SPECIFICATIONS

a. Mainframe must be in YT.

b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

When AVERAGE VALUE is first recalled, the starting and ending points are automatically selected as the first and last points on the displayed waveform.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be processed, (use Autocenter to make this clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel acquired the waveform, (e.g., 1A = Plug-in #1/Channel A).

## EQUATION

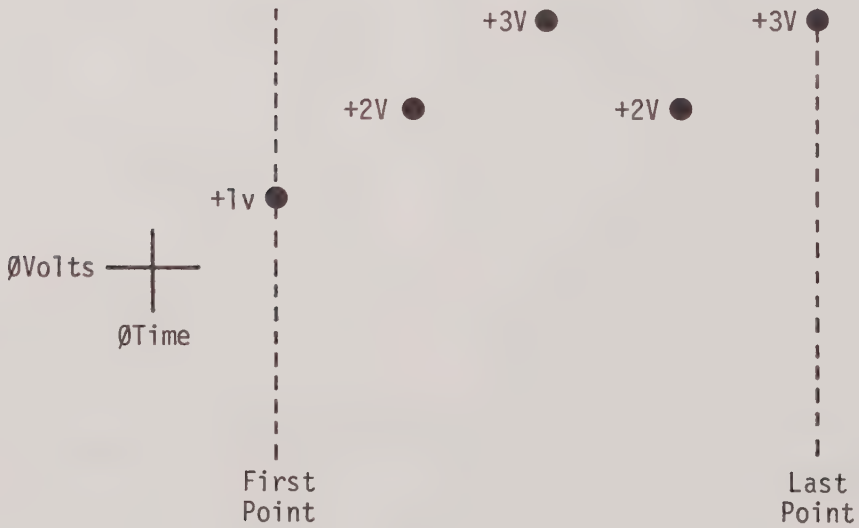
The Computed Average Voltage is stored in the very last waveform address.

$V_1$ = Selected First Point

$V_k$ = Selected Last Point

$$\text{Computed Average Voltage} = \frac{\sum_{n=1}^{k} V_n}{k}$$

## EXAMPLE




$$\text{Average Voltage} = \frac{1+2+3+2+3}{5} \text{ Volts}$$

Time Base = Original Waveform's Time Base

## DESCRIPTION

AVES., # OF SWEEPS is used in conjunction with the plug-in sweep averaging function switch labeled AVERAGE. When executed, the program displays the number of sweeps taken by the plug-in.

If two plug-ins are in use, the displayed count reflects the number of sweeps for the waveform on which the vertical cursor is resting, (use Autocenter to make this clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel acquired the waveform, (e.g., 1A = Plug-in #1/ Channel A).

When a plug-in is put into HOLD LAST, the final count is held. Placing the plug-in back into LIVE will reset the count since LIVE initializes the plug-in and allows new incoming signals to be averaged.

Each plug-in (not each channel) operates independently and can be started and stopped without affecting the count for the other plug-in. To exit the program, press EXECUTE.

NOTE: Exiting the program does not affect the sweep counter.

### SPECIFICATIONS

a. Maximum allowable count is 21,800. If a larger count is attempted, the resulting waveform will deviate from what would be predicted since the sweep count is an important factor in the averaging algorithm.

## DESCRIPTION

CENTERING, Ø VOLTS moves the zero voltage level of all displayed waveforms to the center of the screen. Centering takes place as soon as the EXECUTE button is pressed.

►IMPORTANT: The resultant waveform replaces the original waveform in the memory.

The primary use of this program is to move captured waveforms to the center of the screen so that visual comparisons can be made on waveforms which were acquired with different vertical positioning. It may also be used to make X-Y recorder and photographic records more pleasing to the eye.

The voltage and time values remain unchanged by this procedure.

SPECIFICATIONS

a. Mainframe must be in YT.

b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

c. All waveforms shown on the screen are processed at the same time. To move only one waveform, the MEMORY switch must be used to show only the selected waveform on the screen.

## DESCRIPTION

DIFFERENTIATION computes point to point voltage differentials in a waveform and displays the resulting waveform.

►IMPORTANT: The resultant waveform replaces the original waveform in the memory.

The program prompts the user to select a starting point and an ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory are are automatically recalled if DIFFERENTIATION is used repeatedly.

When DIFFERENTIATION is first recalled, the starting and ending points automatically selected are the first and last points on the displayed waveform. Points lying outside of the chosen starting and ending points are zeroed after DIFFERENTIATION has been completed.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be differentiated, (use Autocenter to make the selection clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel acquired the waveform, (e.g., 1A = Plug-in #1/Channel A).

SPECIFICATIONS

a. Mainframe must be in YT.

b. One waveform may be processed at a time.

It is necessary to use vertical expansion to view the differentiated signal since each computed point rests at a voltage representing the difference between two points on the original waveform. In addition, to avoid overflow, vertical resolution is further reduced by a factor of two. Because of this, the computed difference voltages are generally quite small and the final waveform has a small amplitude.

High frequency noise is enhanced by differentiation since it has relatively large point-to-point voltage changes. Use of the 3 PT. SMOOTHING program is recommended before differentiation to reduce the influence of signal noise.

The DIFFERENTIATION equation is located on the reverse of this page.

EQUATION

$V_1$ = Selected First Point

$V_k$ = Selected Last Point

Computed $V_1$ = 0 (by definition)

Computed $V_n$ = $V_n - V_{n-1}$

where: $(2 \leq n \leq k)$

## DESCRIPTION

DISKETTE COPY makes possible diskette copying in XF44/2 Dual Disk Recorders. The disk recorder on the left should contain the "master" diskette. The right hand disk recorder should contain the "copy" diskette.

NOTE: The "master" diskette should have a protect tab on it whereas the diskette to be recorded must not have a protect tab in place. If a protect tab is found, the numerical display will show "Pro" and the DISKETTE COPY program will be aborted. The title DISKETTE COPY will not be visible after the abort unless the FUNCTION switch is rotated away from "PRGM" and then back again. Absence of the title when the EXECUTE LED is off indicates that the transfer of data has not taken place.

The transfer of data from the "master" diskette to the "copy" diskette takes place even if individual records are protected on the "copy" diskette.

SPECIFICATIONS

a. Copying is limited to 4094 data and program diskettes.

b. Copy time for 4094 data diskettes is approximately 6 minutes.

c. Copy time for 4094 Program diskettes varies from 3 to 6 minutes depending on the number and length of the programs stored on the master diskette.

Standard program diskettes are copyable. Attempts to copy other Program diskettes will result in the message: ORIGINAL DISK IS COPY PROTECTED.

Copy errors will give the message: "ABORT" - VERIFY ERROR on the display screen's status line. All other errors are indicated on the numerical display.

The 4094's plug-in and mainframe remain operational during a diskette copy.

## DESCRIPTION

HORIZONTAL SHIFT is used to move a captured waveform in either a left or right direction along the time axis. The time value associated with each point is not changed in this process. This is equivalent to changing the trigger location before waveform acquisition.

►IMPORTANT: Portions of a waveform shifted off the screen are lost and can not be recovered by shifting the waveform back. The corresponding data points will be represented by a flat line on the left or right side of the screen.

The program prompts the user to select a starting and an ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if HORIZONTAL SHIFT is used repeatedly.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be shifted, (use Autocenter to make the selection clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel acquired the waveform, (e.g., 1A = Plug-in #1/Channel A).

SPECIFICATIONS

a. Mainframe must be in YT.

b. One waveform may be processed at a time.

The location of the starting point will be moved to the location of the ending point upon program execution. All other points on the waveform are shifted accordingly.

## DESCRIPTION

INTEGRATION moves the selected waveform to the center of the screen, computes the integrated waveform, and displays the result.

►IMPORTANT: The resultant waveform replaces the original waveform in memory.

The program prompts the user to select a starting and an ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if INTEGRATION is used repeatedly.

When INTEGRATION is first recalled, the starting and ending points automatically selected are the first and last points on the displayed waveform. Points lying outside of the chosen starting and ending points are zeroed after INTEGRATION has been completed. The final integrated waveform is scaled to fit on the screen and the voltage numerics reflect this change. It should be noted that duty cycle variations, DC voltage offsets, and the chosen starting and ending points will affect the integrated result.

NOTE: Multiple integrations are permissible.

SPECIFICATIONS

a. Mainframe must be in YT.

b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

c. One waveform may be processed at a time.

A computed result lying along a slope merely indicates that a constant voltage was systematically added across the entire waveform. If DC offsets were not intended in the original waveform, the INTEGRATION (AC) program should be used.

The prefixes used when indicating voltages are as follows:

$10^{-6}$ = μ (micro)
$10^{-3}$ = m (milli)
$10^{0}$ = blank
$10^{3}$ = K (kilo)
$10^{6}$ = M (mega)
$10^{9}$ = G (giga)
$10^{12}$ = T (tera)
$10^{15}$ = P (pata)
$10^{18}$ = E (exa)
$10^{21}$ = ?
$10^{24}$ = !

## EQUATION

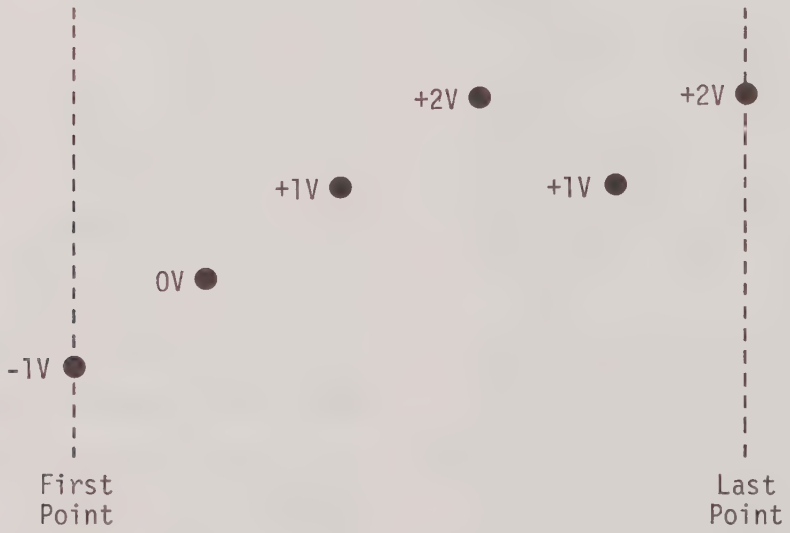
$V_1$ = Selected First Point

$V_k$ = Selected Last Point

Computed $V_n = V_n + V_{n-1} + V_{n-2} + \cdots\cdots\cdots V_1$ where $(1 \leq n \leq k)$

Time Base Of Result = Time Base Of Original

## EXAMPLE




Computed voltage (at third point) = 1+0-1 = 0V

Computed voltage (at last point) = 2+1+2+1+0-1 = 5V

## DESCRIPTION

INTEGRATION (AC) is very similar to INTEGRATION. The only difference is that the average voltage is computed between the starting and ending points and subtracted from every point. This is used to remove unintentional DC voltage offsets which may exist on an acquired waveform.

► IMPORTANT: The resultant waveform replaces the original waveform in the memory.

For the computed average to be equal to the DC voltage offset, it is essential that an integral number of cycles lie between the starting and ending points. DC offsets which vary over the sweep time are not successfully removed. Refer to the INTEGRATION program for the operation specifics.

SPECIFICATIONS

a. Mainframe must be in YT.

b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

c. One waveform can be processed at a time.

## EQUATION

$V_1$ = Selected First Point

$V_k$ = Selected Last Point

$$\text{Computed } V_n = \left[V_n - \frac{\sum_{n=1}^{k} V_n}{k}\right] + \left[V_{n-1} - \frac{\sum_{n=1}^{k} V_n}{k}\right] + \left[V_{n-2} - \frac{\sum_{n=1}^{k} V_n}{k}\right] + \cdots \left[V_1 - \frac{\sum_{n=1}^{k} V_n}{k}\right]$$

where $(1 \leq n \leq k)$

## DESCRIPTION

INVERT moves the selected waveform to the center of the screen, multiplies each data point value by (-1), and displays the result.

►IMPORTANT: The resultant waveform replaces the original waveform in the memory.

The program prompts the user to select a starting and an ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if INVERT is used repeatedly.

When INVERT is first recalled, the starting and ending points automatically selected are the first and last points on the displayed waveform.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be inverted, (use Autocenter to make this clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel acquired the waveform, (e.g., 1A = Plug-in #1/Channel A).

### SPECIFICATIONS

a. Mainframe must be in YT.

b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

c. One waveform may be processed at a time.

The program INVERT is different than the INVERT present on the FUNCTION switch. Program INVERT rotates the waveform about zero volts (ground) while FUNCTION switch INVERT rotates the waveform about screen center (digital zero) which may or may not coincide with zero volts.

## EQUATION

$V_1$ = Selected First Point

$V_k$ = Selected Last Point

Computed $V_n = -1(V_n)$ where $(1 \leq n \leq k)$

## DESCRIPTION

MAXIMUM scans a waveform for the maximum positive (or minimum negative) voltage and moves the horizontal and vertical cursors to the selected data point. The maximum positive voltage is indicated in the voltage numerics after the maximum has been located. If a single waveform has more than one point at the maximum voltage, only the first one will be shown.

The program prompts the user to select a starting and an ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if MAXIMUM is used repeatedly.

When MAXIMUM is first recalled, the starting and ending points automatically selected are the first and last points on the displayed waveform.

SPECIFICATIONS

a. Mainframe must be in YT.

b. One waveform may be processed at a time.

## DESCRIPTION

MINIMUM scans a waveform for the minimum positive (or maximum negative) voltage and moves the horizontal and vertical cursors to the selected data point. The minimum positive voltage is indicated in the voltage numerics after the minimum has been located. If a single waveform has more than one point at the minimum voltage, only the last one will be shown.

The program prompts the user to select a starting point and an ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, the selected starting and ending points remain in memory if MINIMUM is used repeatedly.

When MINIMUM is first recalled, the starting and ending points automatically selected are the first and last points on the displayed waveform.

SPECIFICATIONS

a. Mainframe must be in YT.

b. One waveform may be processed at a time.

## DESCRIPTION

MULTIPLY moves the selected waveforms (X and Y) to the center of the screen, multiplies them together, and displays the result along with the original waveforms. The result is stored in both the second half of the original X and the second half of the original Y data point locations. Half of the original X and Y data points remain untouched.

The primary reason for storing the resulting waveform as described is so that original vs. results can be compared. (e.g., voltage x current = power; voltage vs. power; and current vs. power comparisons can be made.)

The original X and Y waveforms may be acquired on any voltage range or time base. The time base of the result will vary depending on which half is viewed. The half associated with X will have the X time base. The half associated with Y will have the Y time base. Note that the time resolution of the original and resultant waveforms is reduced since each waveform has given up half of the acquired data points.

SPECIFICATIONS

a. Mainframe must be in YT.

b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

Waveforms X and Y must be selected by positioning the vertical cursor on the chosen waveform, (use Autocenter to make this clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel acquired the waveform, (e.g., 1A = Plug-in #1/Channel A).

## EQUATION

$X_n$ = Voltages on Waveform (X)
$Y_n$ = Voltages on Waveform (Y)
Original Waveforms =

$X_1$ $Y_1$ $X_2$ $Y_2$ $X_3$ $Y_3$ $X_4$ $Y_4$ $X_5$ $Y_5$→ etc.

Calculated $X_2 = Y_2 = (X_1) \times (Y_1)$
Calculated $X_4 = Y_4 = (X_3) \times (Y_3)$
Calculated $X_6 = Y_6 = (X_5) \times (Y_5)$

## DESCRIPTION

RISE TIME calculates the time and voltage difference between two points on the rising or falling slope of a waveform.

►IMPORTANT: Execution of this program destroys the original time and voltage numerics.

The program prompts the user to select a starting and ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in the memory and are automatically recalled if RISE TIME is used repeatedly.

When RISE TIME is first recalled, the starting and ending points are automatically selected as the first and last points on the displayed waveform. Typically, the chosen points should lie on a peak and a trough on each side of the slope in question.

RISE TIME calculates 10% and 90% of the voltage difference between the chosen data points. Upon program execution, the plug-in crosshair and the cursor are moved to points near the calculated 10% and 90% values.

SPECIFICATIONS

a. Mainframe must be in YT.

b. One waveform may be processed at a time.

The actual points picked are:

#1. Rise time calculation.
   a. Crosshair at first point greater than 10%.
   b. Cursors at first point greater than 90%,

#2. Fall time calculation.
   a. Crosshair at first point less than 10%.
   b. Cursors at first point less than 90%.

The time and voltage between the 10% and 90% data values is immediately available on the numeric display after completion of RISE TIME. The accuracy of RISE TIME is dependent on the time resolution of the data and signal to noise ratio. Ideally, calculations should be done in areas with plenty of data points and low noise.

## DESCRIPTION

RMS moves the selected waveform to the center of the screen; computes the Root Mean Square (RMS) between the selected start and ending points and stores this value in the last data point of the waveform (far right side of screen); and then displays the average voltage with the horizontal cursor at the correct level. No other data points are changed.

Note: Positive and negative waveform voltages are taken with respect to the original acquisition zero voltage level.

The program prompts the user to select a starting and an ending point on the chosen waveform using the vertical cursor. For convenience during muliple operations, selected starting and ending points remain in memory and are automatically recalled if RMS is used repeatedly.

When RMS is first recalled, the starting and ending points are automatically selected as the first and last points on the displayed waveform.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be processed, (use Autocenter to make this clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel acquired the waveform, (e.g., 1A = Plug-in #1/Channel A).

The calculated RMS voltage is dependent on all characteristics of the waveform including the DC offset, symmetry, duty cycle, and number of cycles chosen, (integral number or non-integral number).

SPECIFICATIONS

a. Mainframe must be in YT.

b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

c. One waveform may be processed at a time.

## EQUATION

$V_1$ = Selected First Point

$V_k$ = Selected Last Point

$$\text{Computed } V_{RMS} = \sqrt{\frac{\sum_{n=1}^{k} (V_n)^2}{k}}$$

## DESCRIPTION

SCALE 0-200% moves the selected waveform to the center of the screen and increases/decreases the displayed waveform's size according to the levels set by the user. This action effectively allows waveforms to be multiplied/divided by a constant.

►IMPORTANT: The resultant waveform replaces the original waveform in the memory.

The program prompts the user to select a starting and an ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if SCALE 0-200% is used repeatedly.

When SCALE 0-200% is first recalled, the starting and ending points are automatically selected as the first and last points on the displayed waveform.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be processed, (use Autocenter to make this clear). The Plug-in/Channel Identifier indicates which Plug-in Channel acquired the waveform, (e.g., 1A = Plug-in #1/Channel A).

SPECIFICATIONS

a. Mainframe must be in YT.

b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

c. One waveform may be processed at a time.

The program will also request selection of a reference point and a new level. These are set by correctly positioning the vertical and horizontal cursors, (Autocenter must be switched off). A reference point chosen outside of the selected start/end range can still be used to scale, but it will not be affected by the scaling action.

NOTES:

#1. If a scaling factor of more than 200% is requested, a scale factor of 200% is used and the reference point voltage is doubled.

#2. If the reference point and the new level are of opposite sign, the scaling factor will be calculated on the absolute value of the two voltages. This permits the reference point to be scaled up/down but it will not be moved to the new level specified since the sign is incorrect.

## DESCRIPTION

3 PT. SMOOTHING reduces the high frequency noise present on an acquired waveform by doing a weighted running average of the selected data points.

►IMPORTANT: The resultant waveform replaces the original waveform in the memory.

The program prompts the user to select a starting and an ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if 3 PT. SMOOTHING is used repeatedly.

When 3 PT. SMOOTHING is first recalled, the starting and ending points automatically selected are the first and last points on the displayed waveform.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be smoothed, (use Autocenter to make this clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel acquired the waveform, (e.g., 1A = Plug-in #1/Channel A).

### SPECIFICATIONS

a. Mainframe must be in YT.

b. One waveform may be processed at a time.

## EQUATION

$V_1$ = Selected First Point

$V_k$ = Selected Last Point

$$\text{Computed } V_n = \frac{V_{n-1}}{4} + \frac{V_n}{2} + \frac{V_{n+1}}{4}$$

Where $(2 \leq n \leq k-1)$

Computed $V_1$ = Original $V_1$

Computed $V_k$ = Original $V_k$

## DESCRIPTION

SUBTRACTION moves the selected waveforms (X and Y) to the center of the screen, subtracts them, and then displays the answer in the memory locations previously occupied by (Y). The resulting time numerics will be those of waveform (Y).

NOTE: Alignment of the X and Y time bases does not occur before subtraction. See the HORIZONTAL SHIFT program if time base alignment is necessary.

NOTE: The resultant waveform may not differ dramatically in physical size from the original waveform, but the numerics will be correct.

Waveforms X and Y must be selected by positioning the vertical cursor on the chosen waveform, (use Autocenter to make this clear).

It is important to remember that each waveform must have been acquired on the same effective voltage range, (voltage range x calibrated probe attenuation).

The time base of the result will be the same as the time base of the original (Y) waveform.

SPECIFICATIONS

a. Mainframe must be in YT.

b. This program repositions the displayed waveform(s) to screen center. See the IMPORTANT note on page 14-1.

The SUBTRACTION program is substantially different from SUB position on the FUNCTION switch. The SUBTRACTION program manipulates waveforms with respect to zero voltage as shown by the crosshair location. The FUNCTION switch position "SUB" manipulates waveforms with respect to the center of the display screen (digital zero) which may or may not coincide with zero voltage.

## EQUATION

$X_n$ = Voltages on waveform X

$Y_n$ = Voltages on waveform Y

Computed $Y_n = X_n - Y_n$ (See note 1)

Computed Time Base = Time Base of Waveform Y

(Note 1: Vertical resolution is reduced by a factor of 2.)

## DESCRIPTION

TITLE allows the user to create up to four unique titles (T1, T2, T3, and T4) and store them in the display memory locations (Q1, Q2, Q3, and Q4, respectively). The titles can contain up to 32 characters each and will appear on the Status Line at the top of the display screen.

Titles written on the Status Line are stored into memory after exiting from the program. In addition, the titles saved in memory can also be stored on diskettes and be recalled along with normal waveform data. The titles can also be included with digital plots of waveform data.

Titles are written by manipulating the horizontal and vertical CURSOR control buttons. The left/right buttons position the vertical cursor to the next character location. The up/down buttons allow character selection. Holding the AUTOCENTER switch in the spring loaded "ZERO" position while moving the cursor allows rapid erasing of existing titles.

The completed title can be moved, as a unit, left/right by switching into DATA MOVE (while still executing the TITLE program) and manipulating the left/right CURSOR buttons. Care should be taken, however, since titles moved off the display to the left or right are lost from memory.

After completion of a title, use the MEMORY switch to determine which title locations are to be updated with the new title before exiting the program via the EXECUTE button, Table #1).

| MEMORY POSITION AT EXIT | NEW TITLE LOCATION |
|---|---|
| ALL | T1,T2,T3,T4 |
| H1 | T1,T3 |
| H2 | T2,T4 |
| Q1 | T1 |
| Q2 | T2 |
| Q3 | T3 |
| Q4 | T4 |

*Table #1*

The completed title can be seen when the FUNCTION switch is moved away from "PRGM." The relationships between title location in memory and where the title can be viewed is shown in Table #2, located on the reverse of this page.

| TITLE | MEMORY POSITION WHERE TITLE IS VISIBLE |
|---|---|
| T1 | ALL, H1, Q1 |
| T2 | H2, Q2 |
| T3 | Q3 |
| T4 | Q4 |

*Table #2*

Titles saved in memory are not lost by the actions required to take in new waveforms. Titles can be destroyed only by:

a. Purposely erasing them, or
b. Turning off the oscilloscope, or
c. Recalling new ones from a diskette.

It is possible, therefore, to title experiments, dates, etc., and have the title appear with all new waveforms without the necessity of rewriting them each time. Titles will be stored on the diskette if the FUNCTION switch is not in the "PRGM" position; otherwise blanks will be stored in the title position on the diskette.

When storing titles and waveforms on the disk recorder, all titles (even those not visible) will accompany their corresponding waveforms. For example; Q1, Q2, Q3, and Q4 each contain a unique waveform and title.

All four waveforms and titles can be stored on a single diskette record if the MEMORY switch is placed to the "ALL" position during a diskette recording.

● TRANSFERRING TITLES

Since the title location is determined by the position of the MEMORY switch when exiting the program, it is possible to transfer a title (either verbatim or modified) from one memory location to another.

EXAMPLE

The title "EXPERIMENT #1" is stored in Q1 and it is desired to title a waveform in Q2 as "EXPERIMENT #2." To accomplish this:

#1. MEMORY switch: Q1

#2. Enter TITLE program.

#3. Alter "EXPERIMENT #1," displayed on the Status Line, to read "EXPERIMENT #2."

#4. MEMORY switch: Q2

#5. EXECUTE button: Press.
    a. The waveform stored in Q2 is now titled "EXPERIMENT #2."

## DESCRIPTION

VERTICAL SHIFT is used to move a captured waveform either up or down on the display screen. The voltage associated with each data point is not changed in this process. This is equivalent to changing the POSITION control before waveform acquisition.

►IMPORTANT: The resultant waveform replaces the original waveform in the memory.

Portions of a waveform not chosen to be shifted will have voltage values changed since the zero voltage location has been shifted along with the shifted portion of the waveform.

The program prompts the user to select a starting and ending point on the chosen waveform using the vertical cursor. For convenience during multiple operations, selected starting and ending points remain in memory and are automatically recalled if VERTICAL SHIFT is used repeatedly.

When VERTICAL SHIFT is first recalled, the starting and ending points are automatically selected as the first and last points on the displayed waveform.

SPECIFICATIONS

a. Mainframe must be in YT.

b. One waveform may be processed at a time.

If multiple waveforms are displayed, only the waveform on which the vertical cursor is resting will be shifted, (use Autocenter to make the selection clear). The Plug-in/Channel Identifier indicates which Plug-in/Channel acquired the waveform, (e.g., 1A = Plug-in #1/Channel A).

The program will also request a reference point on the waveform and a new level. These are set by positioning the vertical and horizontal cursors, (Autocenter must be switched off).

The selected reference point is shifted to coincide with the new level during program execution. A reference point lying outside of the chosen starting and ending points is acceptable, but will not be shifted.

Excessive movement of a waveform, up or down, will cause it to "wrap around" and appear on the opposite

side of the screen. A waveform which has wrapped around can be recovered by an additional vertical shift in the opposite direction.

## INTRODUCTION

The following special procedures have been included to serve as guidelines when performing "critical" measurements, or measurements requiring special considerations.

The preceding pages of this manual should be read before applying these discussions.

► IMPORTANT: The term "Hold mode" will be used in the following discussions to signify that the Plug-in is in the Hold Last mode. (The LIVE and HOLD NEXT LEDs are off and only the HOLD LAST LED is illuminated.)

## SETTING UP FOR SLOW SWEEPS

The basic operation of the oscilloscope remains unchanged regardless of the time per point selection.

However, certain precautions in the setup should be observed when very slow sweeps and/or long delays are involved because there is no immediate visual feedback to indicate that the signal is being successfully captured.

Therefore, whenever possible, simulate the expected signal and execute several practice measurements to ensure the controls have been properly positioned.

NOTE: A faster time per point can be selected to expedite the practice sweeps. However, be sure to return the TIME PER POINT switch to the required position before executing the final measurement.

IMPORTANT: Always press the HOLD LAST button after the sweep has been triggered. This will help guard against an accidental loss of data upon the completion of the sweep.

The approximate sweep times are tabulated in Table 8-4, page 8-17 under the *Plug-ins* tab.

## TERMINATING SLOW SWEEPS

To terminate a slow sweep, momentarily press the LIVE button while, at the same time, holding in the HOLD LAST button. The Plug-in will enter into the Hold mode, indicating that the sweep has been successfully terminated.

NOTE: Do not select a faster time per point to expedite sweep completion. This may cause the oscilloscope to record the wrong normalization and the time numerics will be in error.

## CAPTURING SINGLE EVENTS

A single event can be captured by pressing the LIVE button and then the HOLD NEXT button (before a valid trigger is generated), This action will allow only one sweep to be triggered. The Plug-in will enter the Hold mode upon the completion of the single sweep, retaining the collected data in the memory.

When possible, simulate the expected signal and execute several practice measurements to ensure the controls have been properly positioned.

► IMPORTANT: Always press the HOLD NEXT button - BEFORE - a valid trigger is received. Otherwise, a second sweep will replace the data collected during the first sweep.

## MULTIPLE TRIGGER MODES

The Normal, Cursor and Delayed trigger modes can be mixed or matched when multiple channels are acquiring data. See *Plug-ins* tab, page 8-38 for detailed descriptions.

● SINGLE PLUG-IN OPERATION

A single trigger applied to either channel A or B, or the EXT input BNC will initiate a sweep for both channels. However, the only time that both channels will simultaneously acquire data for display is when:

#1. Both channels are operating in the Normal trigger mode, or

#2. Both channels are operating in the Cursor (or Delayed) trigger modes and identical delays have been selected.

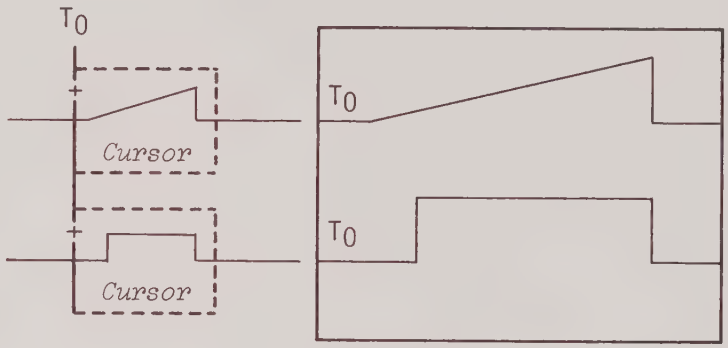
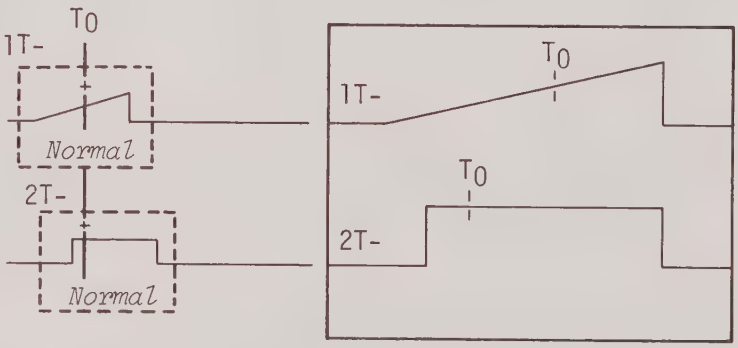
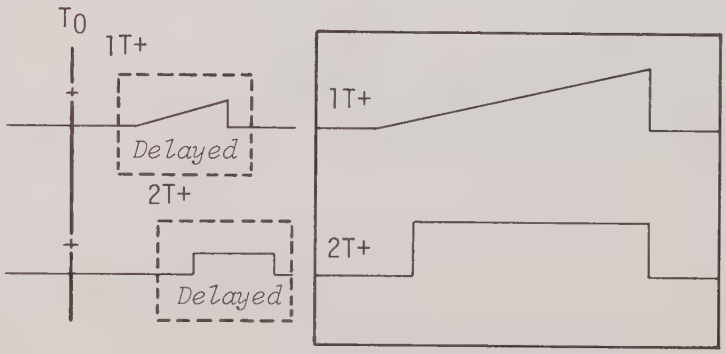
Therefore, when viewing displays acquired with different trigger modes (or identical trigger modes with different delays), it is important to remember that the displayed data groups are, with respect to each other, displaced in time.

Figures 15-1 thru 15-6 illustrate the relationships of the displayed data groups for each one of the possible combinations of trigger modes.

NOTE: The term ($T_0$), in the following figures, represents the position of the Plug-in's trigger cursor, or "Time Zero." Placing the Mainframe's vertical cursor at the extreme left-hand edge of the screen and selecting channel A or B by consecutive taps on the left/right cursor buttons will result in a numerical display of the repsective channel delay indicated in the figures.

In addition, assume that the following examples of signals were acquired while in the External trigger mode.

••Matching Trigger Modes

| NORMAL/NORMAL | |
|---|---|
| Extreme left of screen always corresponds to the ($T_0$) origin for both channels. The ($T_0$) origin corresponds to the time at which acquisition began on each channel. |  *Figure 15-1* |
| CURSOR/CURSOR | |
| Extreme left of screen corresponds to each individual (T-) time origin for both channels. The (T-) origins correspond to the time at which acquisition began on each channel. Identical (T-) origins will only occur when identical delays have been selected. |  *Figure 15-2* |
| DELAYED/DELAYED | |
| Extreme left of screen corresponds to each individual (T+) time origin for both channels. The (T+) origins correspond to the time at which acquisition began on each channel. Identical (T+) origins will only occur when identical delays have been selected. |  *Figure 15-3* |

••Mixing Trigger Modes

| NORMAL/CURSOR |
|---|
| Extreme left of screen corresponds to the ($T_0$) time origin for the *Normal* trigger signal and (T-) for the *Cursor* trigger signal. The ($T_0$) and (T-) origins correspond to the time at which acquisition began on each channel. |

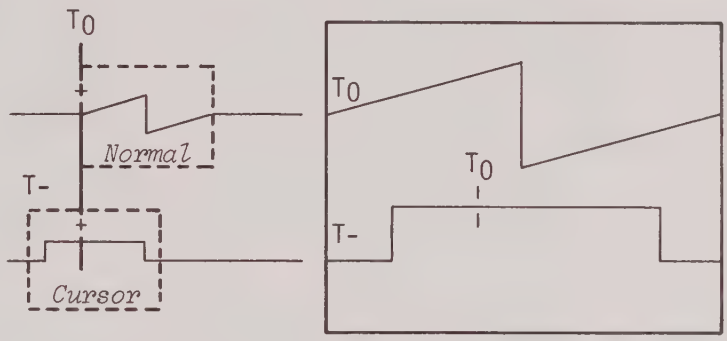



*Figure 15-4*

| NORMAL/DELAYED |
|---|
| Extreme left of screen corresponds to the ($T_0$) time origin for the *Normal* trigger signal and (T+) for the *Delayed* trigger signal. The ($T_0$) and (T+) origins correspond to the time at which acquisition began on each channel. |

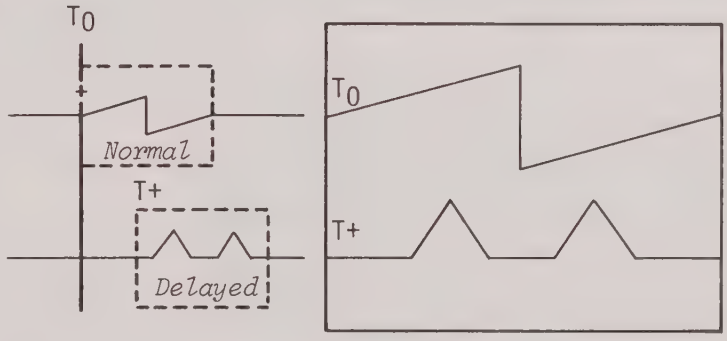



*Figure 15-5*

| CURSOR/DELAYED |
|---|
| Extreme left of screen corresponds to the (T-) time origin for the *Cursor* trigger signal and (T+) for the *Delayed* trigger signal. The (T-) and (T+) origins correspond to the time at which acquisition began on each channel. |

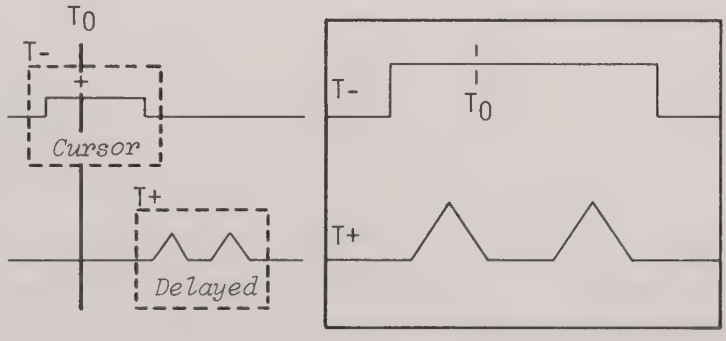



*Figure 15-6*

● TWO PLUG-IN OPERATION

When employing two Plug-ins to acquire data, the operator can elect to trigger both Plug-ins simultaneously with a common trigger, or trigger each Plug-in individually with two separate triggers. See *Plug-ins* tab, page 8-38 for detailed descriptions.

Regardless of which manner of triggering is selected, the overall effects previously described for a single Plug-in (two channel) display remains the same.

Figure 15-7 illustrates the effect of triggering a sweep from a common trigger applied to the "master" Plug-in when the "slave" Plug-in's trigger SOURCE switch is in the "S" position.

Figure 15-8 illustrates the effect of triggering sweeps on each Plug-in with a different trigger.

NOTE: The term ($T_0$), in the following figures, represents the position of the Plug-in's trigger cursor, or "Time Zero." Placing the Mainframe's vertical cursor at the extreme left-hand edge of the screen and selecting channel A or B by consecutive taps on the left/right cursor buttons will result in a numerical display of the respective channel delay indicated in the figures.

In addition, assume that the following examples of signals were acquired while in the External trigger mode.

## COMMON TRIGGER

Illustrates the effect of applying a common trigger to the "master" Plug-in when the "slave" Plug-in's trigger SOURCE switch is in the "S" position. The extreme left of screen corresponds to the time at which acquisition began on each individual channel.

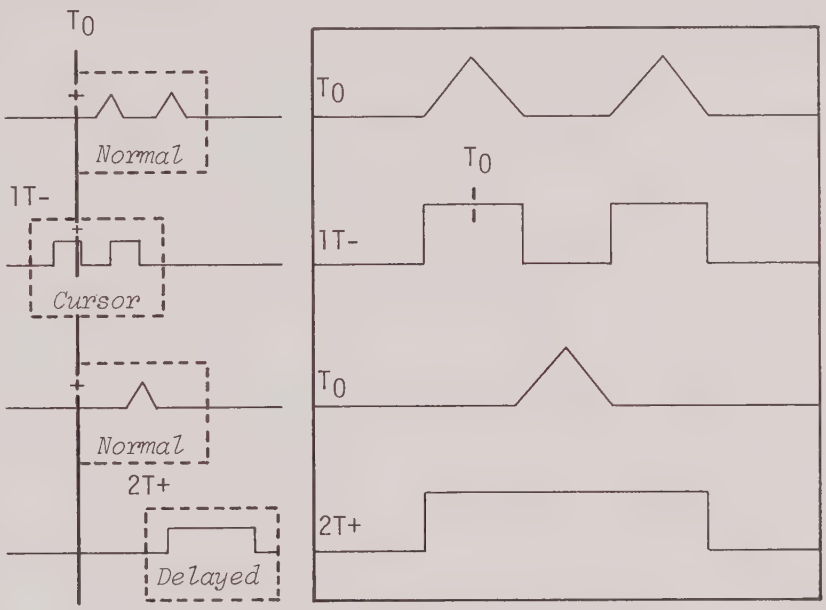



*Figure 15-7*

## SEPARATE TRIGGERS

Illustrates the effect of applying separate triggers to each Plug-in, providing each Plug-in with a different trigger time ($T_0$) origin. The extreme left of screen corresponds to the time at which acquisition began on each individual channel.

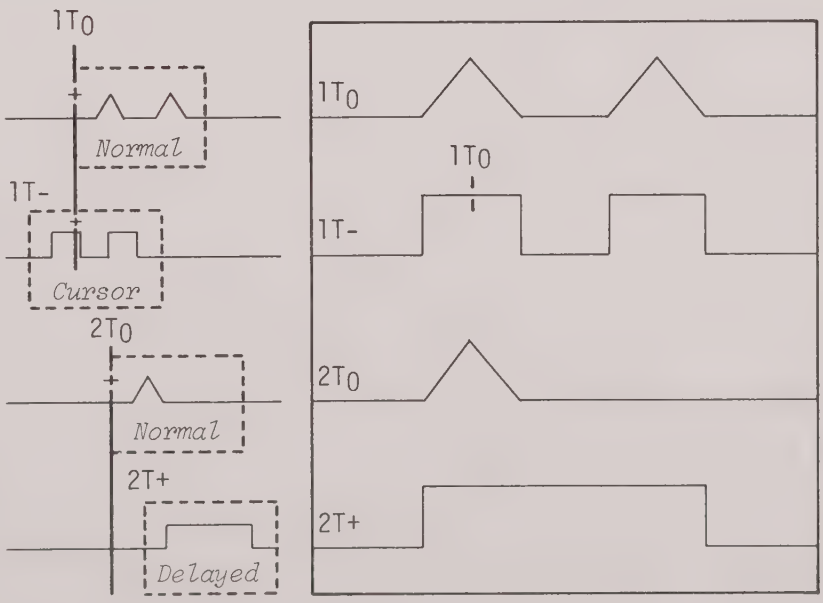
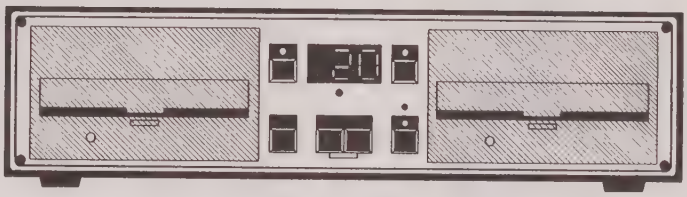


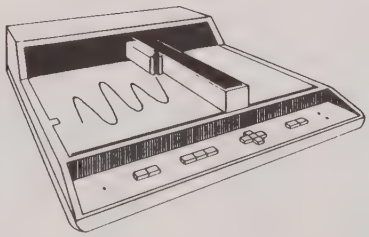

*Figure 15-8*

## INTRODUCTION

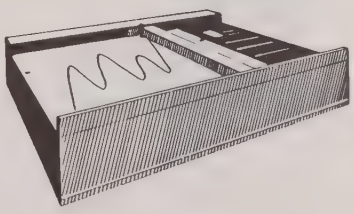
NOTE: Specific operating instructions for the Digital Plotter are not available at this time. They will be immediately forwarded upon completion.



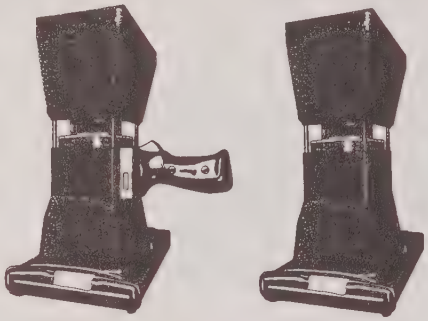
DUAL DISK DRIVE - *The XF-44/1 (single drive) and XF-44/2 (dual drive) disk recorders provide a simple means by which signals can be permanently recorded for later recall. The XF-44 provides all of the features of the F-43 Disk Recorder. The XF-44/2 configuration provides the additional "diskette copy" feature.*



H.P. DIGITAL PLOTTER - *Plots on standard 8-1/2" x 11" paper. Permits multiple plots with 7 selectable dashed-line fonts and includes alphanumeric labeling.*

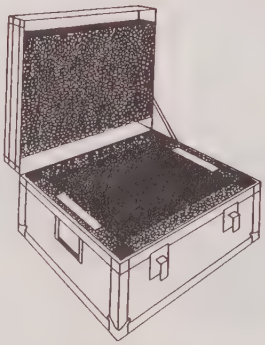


XY PLOTTER - *Available in either 8-1/2" x 11" or 11" x 17" plotter configurations with rackmount brackets and BNC inputs.*



SCOPE CAMERA - *Polaroid* CU-5 or Shackman lightweight, pack film cameras using Polaroid 3-1/4" x 4-1/4" (8.3 x 10.8 cm) self-developing film.*

10X PROBE - *10 Megohm input resistance when used with scopes with 1 Megohm input. 100 MHz bandwidth, 600 volts DC working voltage, 59" (1.5 m) cable length.*



CARRYING CASE - *Sturdy 1/8" polyethylene plastic with steel-reinforced corners, four latches and two recessed handles. Protective inserts of Ethafoam ** plastic. Approximate dimensions: 23-1/4" (59 cm) wide by 22" (55.9 cm) deep by 13" (33 cm) high. Weight is 35 lb (15.75 kg).*

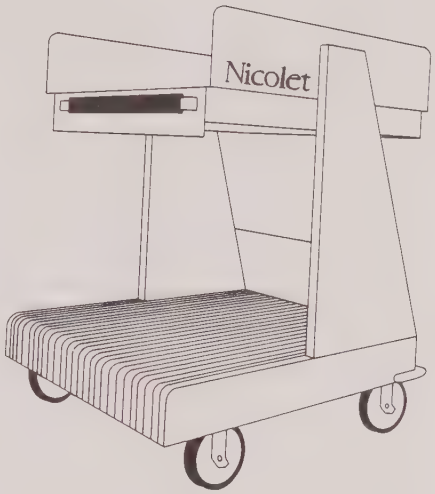
DUST COVER - *Heavy duty, leather grained vinyl material reinforced on the front panel, edges and corners for added protection. Includes quick seal Velcro*** strips for fast access, detachable pouch for accessories and a slotted top for access to the carrying handle.*

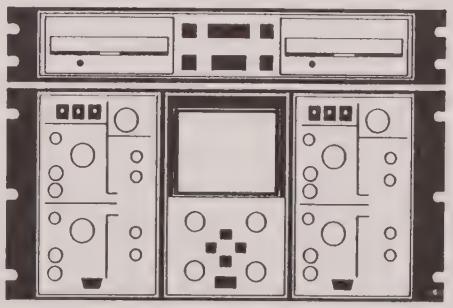
* *Reg. tm. Polaroid Corp., Cambridge, MA*
** *Reg. tm. Dow Chemical Co., Midland, MI*
*** *Reg. tm. Velcro USA Inc., New York, NY*

SCOPE CART - *Versatile, enamel finished oscilloscope cart on easy rolling 2-1/2" casters. Includes 3 power outlets, self-contained storage drawer, front mounted castor brakes, and tray which can be angled up to 35°.*

*Approximate dimensions: Top surface is 17-1/2" (44.5 cm) deep and 18" (45.72 cm) wide. Overall dimensions, including casters and rear bumper guards, are 35-1/4" (87 cm) high by 21-1/4" (54 cm) wide by 24-3/4" (63 cm) deep.*

*Approximate weight is 80 lbs (36 kg).*



RACK MOUNTS - *Separate rack mounts for the 4094 oscilloscope and XF-44 Disk Recorder are manufactured from 1/8" angle aluminum drilled to fit a standard 19" (48.26 cm) rack or cabinet.*

## PARTS LIST

The Parts List will be immediately forwarded upon completion.

# SCHEMATICS

The Schematics will be immediately forwarded upon completion.